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SYMPOSIUM ON THE FUNCTION AND ORGANIZATION OF THE BIOLOGICAL SCIENCES IN EDUCATION.

It is the purpose of the editors of the departments of botany and zoölogy to present to the readers of the magazine a considerable number of brief statements from those science men who have given attention to the educational as well as the academic aspects of their various subjects. The first of this series of discussions is herewith presented, and it is expected that others will follow in the next issue of the magazine. Brief and pointed contributions to this symposium will be welcomed, and should be sent direct to one of the department editors concerned. While the above topic should be the one generally considered, the different discussions may properly take any one or all of the following trends, or indeed may take a line of thought not included in the following:

What is the purpose of biology in education?

What are the practical, pedagogical, and scientific bases for the study of biology in secondary schools?

Should the study be based upon the conception of biology as a single science, using plant or animal material as occasion requires for developing principles, or should it consist of separate sub-courses or entirely distinct courses in botany, zoölogy and human physiology?

Should biological courses give more attention to the economic or industrial aspects of the materials involved?

BIOLOGY IN SECONDARY SCHOOLS.

By Maurice A. Bigelow,

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Looking at the problems of high-school biology from the standpoint of the great majority of pupils, not from that of the selected few whose interests or plans may sometimes demand special arrangement of courses, my answer to the Departmental Editor's question, "Should the high-school biology be one based on the conception of biology as a single science, using plant or animal materials as occasion demands for developing principles, or should it be separate sub-courses or entirely distinct courses in botany, zoölogy, or human physiology?" is "yes" for the first part of the question and an emphatic "no" for the second part. And the following considerations point to such a conclusion:

The practical problems of the high-school curriculum, viewed from the standpoint of school administration, demand concentration of the biological work into one course *adapted for the great majority* of pupils. Here are the facts in support of this: (a) It is generally admitted that four science courses, one for each year, offer the maximum amount of science desirable for the average secondary-school pupils. (b) Chemistry, physics, botany, zoölogy, human physiology, earth science—a total of six—are the sciences which must be taken into consideration. (c) There are two possible solutions, namely election or concentration. (d) Election means that pupils will fail to get a broad outlook on the field of natural science, and *possibly of all biology*. (e) Concentration of the biological work into one course would leave biology, physics, chemistry, earth science—one for each year of the high school. This looks reasonable from the standpoint of school administration, but is a year in biology satisfactory from the viewpoint of the biologist?

From many quarters we hear the objection that botany and zoology have developed into quite separate sciences; and this statement is true in most colleges where research for the few rather than liberal biological training for the many prevails. However, it is now high time that secondary-school teachers of biology begin to distinguish between technical zoölogy and botany viewed as courses leading directly to research and liberal biological courses designated to teach the great ideas or principles of the

life sciences with reference to the needs of the average well-educated citizen. Viewed from this standpoint botany and zoology are not properly two sciences. And this is the standpoint which should be taken in secondary schools where the great majority of pupils are completing their formal education rather than preparing for college. More than anything else high-school teachers of biology need to study more seriously the problems of teaching the science with reference to the ideals of liberal secondary education considered as an end in itself rather than as college preparation. Viewed in this way the teaching of biology in the secondary school becomes the selection and presentation *not so much of the facts as of the great ideas or principles* which may be drawn from organized study of a series of plant and animal forms, and the unified course in biology becomes a logical necessity.

But from the four winds comes the protest that botany and zoölogy are so vastly rich in materials that even with a year for each they can not be "finished." I must confess that I have not been able to get into sympathy with this protest. Why should we want to "finish" botany or zoölogy in one year or even in five, so far as secondary education is concerned? We do not "finish" other subjects in the high school. On the contrary we simply select materials for well-rounded year courses. Certainly we cannot complete a wide survey of either of the biological sciences in a single year, but there are great possibilities of selection when our outlook on high-school science becomes that of liberal education as distinguished from technical education. Take any current high-school book on zoölogy or botany and go through the pages critically questioning each paragraph from the point of view of education for general culture and information, and one is amazed at the amount of matter for which little justification is apparent. Eliminating such material of questionable value, it seems perfectly feasible to combine the essentials, the great ideas, of the two phases of the science of life into a single course. Such a course with its broader outlook would be more valuable to the average educated citizen than would be either botany or zoölogy studied without reference to its sister science. Even laying entirely aside the practical problems of school administration, which are certainly tending to limit biology study to a single year for the average pupils, I believe that ultimately our high schools will adopt a year course in

biology because such a course will best include the important values of biology in secondary education.

The above discussion has included only the information side of the values of high-school biological study. Limitations of space forbid appropriate discussion of the scientific discipline derivable from the study; but I fail to see any valid argument against the year in biology as far as discipline is concerned. On the contrary we may expect to get more valuable scientific discipline from the study of the more important subject-matter which would be concentrated into a year of biology. The possible objections all center around the idea that science study must be carried far into useless detail in order to give the best scientific discipline. This may be true from the research standpoint; but as applied to the everyday life of the average cultured citizen the results of such study of details have been far from satisfying. We seem to be moving rapidly towards that science study which is so correlated with information worth having that the discipline obtained will meet with greater application in practical life.

Summary: The practical problems of the school curriculum seem to demand a course in biology for the majority of pupils, and there is nothing in the content of the science and in approved methods of teaching which opposes this. Considering the recognized values, a course in biology will tend to emphasize the great ideas or principles worth knowing, and there is no inherent reason why scientific discipline should not be as well developed as in any other high-school course in science.

THE PRACTICAL, PEDAGOGICAL AND SCIENTIFIC BASES FOR THE STUDY OF BIOLOGY.

By Benj. C. Gruenberg,

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The "practical" in education has until recently meant, and to most still does mean, that which gives the individual an advantage in his competition with others. As education becomes both public and universal the "practical" must come to mean that which gives the community the advantage in its struggle against its environment, animate and inanimate. The welfare of a civilized community depends, and will with the years more and more depend, upon, *inter alia*, the degree to which its citi-

zenry coöperates in the public activities directed towards the maintenance of general health, the conservation of natural resources, and the advancement, through research and organization, of man's control of his environment. So much of the daily activity of a large part of the population in every civilized community depends upon the application of biological knowledge, so much of the public activity consists in the application of biological knowledge, that if the citizens are to coöperate intelligently and efficiently it is necessary that they shall in ever increasing proportions be sufficiently well informed to understand the facts and principles upon which these activities are based, even where each is not directly engaged in these activities. It is of great practical importance that at least all who get a high-school training shall understand the bases for society's fight against various plants and animals whose activities are of direct or indirect economic or hygienic bearing; the bases for vaccination, and quarantine and food-inspection; the bases for restricting hunting and fishing and water-polluting and forest-destroying. It has been possible in the past to teach people to abhor the thought of mixing milk with flesh, or of eating meat on Friday, or of laughing on Sunday; it would be just as easy, and practically much more desirable, to teach people to shrink at the thought of violating any of the restraints or demands upon our conduct imposed by an understanding of the biological foundations of hygiene or of economic welfare. The fact that we are living beings whose well-being depends more and more upon an understanding of our external relations to other living beings, and of the internal processes of living things, furnishes the practical bases for the study of Biology.

In common with other high school subjects, the study of Biology must contribute to the amplification and the deepening of the pupil's interests and sympathies; to the elaboration of his thought processes and to the facility of his thought expression. In common with the other sciences it must cultivate the habit of looking to facts for the foundations of opinions, and must give him some skill in discerning facts through observation and experiment; it must cultivate the habit of analyzing problems and looking for causal relations, and must give him some skill in distinguishing between essentials and incidentals in various classes of phenomena; it must impress strongly upon the pupil an appreciation of the debt of civilization to science as method,

and the living faith that in all matters knowledge is better than ignorance, and choice better than chance. In addition, high school Biology must cultivate on the one hand an appreciation of what human life has in common with plants and with other animals, and on the other hand a strong and highly differentiated feeling for relative values; at the same time it must counteract the tendency to consider man as the end of the universe, either in the sense that all exists for his especial benefit, or in the sense that he is in his present state the final product of all evolution. To relate these various ideas to the activities of everyday life is a part of the pedagogical problem.

The scientific bases for the study of Biology are the fundamental problems that apply to all living things: comparison of living and non-living; properties of protoplasm, and the activities and capacities of organisms conditioned thereby; the notion of life as adjustment; the conditions essential to life and the limitations upon its continuance; the essentials of nutrition, the Nitrogen, Carbon and Oxygen balances; the relations of plants and animals to each other and to man; interdependence, types of symbioses, communal life; organization as integration and differentiation; reproduction and the essentials of sex; tropisms, taxes and instincts; increasing importance of consciousness in utilization and control of environment; variation and heredity; artificial selection and hybridization, etc.; evolution and man's place in nature. If the high school, and especially the public high school, is to give its pupils anything more than what passes under the name of "culture" in the boarding-schools for young ladies of the well-to-do middle class, surely these scientific ideas and their related ideals and effects upon conduct are eminently worth while; at any cost we cannot afford to do without them.

The structure of the Biology course will depend upon the end in view. If we are to present *Biology* at all we must teach it as a single science. To teach Botany, Zoölogy and Human Physiology in one year as three subjects is to sacrifice thoroughness or balance; and there is not enough material of sufficiently general interest or importance in any one of these to justify the expenditure upon it of the full time for a year. The most important part of each of these subjects lies just in those things that can be most easily and most profitably correlated with the things in the other subjects; but the most useful synthesis and perspective cannot be readily obtained if the matter is presented

as under separate subjects, and is generally not obtained at all when so presented. The single Biology course can give all that is necessary of the strictly botanical and of the strictly zoölogical and of the strictly physiological; it alone can give the more generalized material in a thorough, balanced and coherent way.

THE BASIS OF THE TEACHING OF BIOLOGY IN SECONDARY SCHOOLS.

By C. Stuart Gager,

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The subjects that may be taught in schools below college fall naturally into two groups: first, the tools of education, such as reading, spelling, number, a knowledge of which is necessary to the study of any others; second, all other subjects. But no one, I suppose, would now argue that, because reading and number have a utilitarian value with reference to the pupil's further schooling, they should not be taught at all unless the pupil is to proceed further than the elementary grades. A knowledge of these subjects has another value than merely that of a gateway to history, literature and the sciences as taught in school. Knowing how to read enables the pupil whose formal education may stop with the eighth grade, to broaden his interests and his general intelligence after leaving school, and to become a more useful and desirable member of society. Therefore reading, spelling, *et cetera,* should be taught, not only because they prepare the pupil for the high school, but because they fit him for more complete living in case his school course is not continued.

When we consider what subjects should be included in the high school course of study, the fundamental question first arises: What is the object of the high school course? Is it to prepare for college, or to continue the process, begun in the lower grades, of equipping the pupil for more complete living and more effective social service? Space is too brief to discuss here what the purpose of a high school course should be, but I take the position that we should insist upon the latter purpose rather than the former.

On this basis, the question of the inclusion or exclusion of different studies from the high school curriculum is to be decided on their relative value as instruments to accomplish the end indicated.

Social efficiency and individual happiness go hand in hand, and vary directly with the breadth of one's interests, his understanding of his environment in time and space, and of his own relation to that environment, and the correctness of the perspective with which he views himself, and the men and things about him. The most nearly perfect adjustment depends upon the personal equations of knowledge, sympathy, and habit of thought.

The high school curriculum, then, should include subjects which broaden one's interests, put him in touch with past events, make him intelligent about the phenomena that form part of his daily experiences, enable him better to judge relative values, and train him in correct habits of thought and work.

In how far does the high school education fall short of doing this if biological science is omitted? It seems to me that the question proposed for discussion in this symposium can be answered satisfactorily only on the basis of these broader principles. To say that botany should be studied so that one may know the names of the trees and the wild flowers, zoölogy to learn the names of birds, human physiology merely for the information it conveys is only to present a very inadequate plea.

The concrete arguments have been stated again and again, but those who need arguments will probably never be convinced in that way. The very fact that the biological sciences need an advocate indicates the inadequacy of an education in which these subjects have been neglected, and whose product is a too narrow outlook and breadth of sympathy and interests.

I have emphasized the pedagogical basis for the study of biology in secondary schools. If the subjects are correctly taught the information will result as a matter of course, and there is the scientific basis. A satisfaction of the informational and educational needs is, *ipso facto,* practical. Such questions as the preservation of the forests, of marine vertebrates, and of other natural national resources will be more surely settled aright by citizens whose education has been founded in harmony with the principles here indicated.

As to whether the subject-matter should be presented as one subject, biology, or as separate subjects, botany, zoölogy and human physiology, I think is a less important question than as to whether or not such subject-matter should be presented at all.

The practice will, and doubtless should vary with the special conditions obtaining at any given school, with the laboratory equipment, and more especially with the preparation of the teacher. I believe that how the subject is taught is vastly more important than which subject is taught.

To summarize: the practical, pedagogical, and scientific bases for the study of biology in secondary schools are:

To give an added interest in life.

To give the pupil a more nearly adequate conception of his environment, and of his own relation to it than is possible if biology is neglected.

To give discipline in a method of thought not conferred by non-scientific subjects.

To offer a corrective for a perspective that, without such studies, is too much distorted.

THE FUNCTION OF THE BIOLOGICAL SCIENCES IN EDUCATION.

By T. W. Galloway,

There are, broadly speaking, two ways in which a department of human effort may contribute to the work of educating the youth: (1) it may contribute to our knowledge of the meaning of the educational process, its role and method in the race and in the individual; and (2) it may serve, in the subject-matter or in the method necessary to its mastery, a valuable place in the development of the individual. Biology is vitally valuable to the educational program in both these respects.

I. *The role of the biological sciences in delineating the general ideals, purposes, matter and methods of education.*

There is no purpose to enter largely into the discussion of this phase of the contribution of Biology to education. It is simply impossible to overstate the degree to which biological research is now at the basis of modern work in Psychology, Pedagogy, Child Study, Philosophy, Sociology, and Ethics—all of which are immediately cognate to education.

1. Through the extension of the idea of organic evolution we have entered upon a practical recognition of the unity of human and sub-human processes. Because of this we have come to recognize that human education is only a special case under the great problem of life itself. Therefore we recognize that

biological data are as basal to education and morals as they are to digestion and medicine. Nothing comparable to this conclusion has ever occurred in giving a cosmic quality to education.

2. More specifically, through our studies of life, we have come to realize that adaptation or adjustment—coupled with the retention of the quality of adjustability—is the goal of evolution in life; so we understand that the education of the human individual is a consciously organized and directed effort to secure the adjustment of the child to the more important conditions of human life, and at the same time to increase his power for renewed adjustment. To be sure the process is accelerated and artificial because of the great complexity and artificiality of our modern social conditions, modified by that wonderful accumulation of wisdom and rubbish which we call knowledge. In this necessary artificial acceleration of the individual development, it is reassuring to have back of us this great biological analogy between education and life.

Adaptation does not mean merely that the visitor to Rome must imitate the Romans, or that a square plug shall be made to fit a round hole, but that education and life are to secure for each individual, as nearly as possible, the power to respond properly, from within, to all the vital stimuli (from water to Deity), which impinge upon his personality (whether the appeal is to thirst or to God-consciousness).

3. From these considerations we are reaching a most wholesome conclusion, namely: that human education is a great experiment in which we are trying to evaluate the natural and the artificial elements so as to control the output in accordance with the momentary best ideals of the race. We are recognizing that any equilibrium we may reach is a moving equilibrium. The study of Biology has been a back-set to dogmatism and to premature certainty in Theology no more than in education. Few other gains made by educators are comparable in importance to this.

4. The study of living objects and the identification of education with life has gradually caused us to put the emphasis on the individual to be educated rather than upon the subject taught. The value of this gain is difficult to overstate.

II. *The function of biological studies in the development of adaptation and of adaptability in the individual.*

1. In common with other laboratory sciences Biology is believed to present certain educational values. These can only be enumerated here. Under proper conditions all of these sciences tend to train in the accurate use of the senses, in skill in manipulation, in exactness and adequacy of expression; they train in the comparison of qualities and of objects, in the discrimination of the essential from the accidental qualities, in self-reliance in reaching conclusions from one's own observations—and, if used honestly, in willingness to revise and recast conclusions in the light of new evidence.

2. It is believed, however, that there are certain points of *special* value possessed by Biology, not possessed by the other laboratory sciences in equal degree, if at all.

(a) To those who regard the getting of information as the prime means of securing individual adaptiveness there is sufficient practical value to the biological data to make it worth while. Much of it is vital to normal bodily functioning, to medicine, to domestic and social economy, and to industries of various kinds. But of these I do not care to speak.

(b) The content and the natural method of presenting Biology exalt the concept of growth and development toward a result. In reaching this result they stress fitness and efficiency and a close and adequate adjustment of means to ends. These things must furnish a good substratum for character.

(c) Biological studies, pursued in the modern way, make an insistent demand that the student compare himself with the object studied. This is possible nowhere except in the biological sciences and their specializations. This reacts on the knowledge of the self and the physical, physiological, mental and moral processes without hurtful introspection — allowing concrete checks on introspection. The educative value of this attitude may be illustrated by the sane way in which the problem of sex, and its place and meaning in personality, may be brought to the knowledge of youth, without any taint of pruriency. It assists in decentralizing man from the pivotal point in the universe.

(d) No other discipline is equal to *Biology* in enabling the student to distinguish *cause* from *gain* or *advantage*. All educators who study the child-mind will realize the necessity of this, and its difficulty.

(e) The omnipresent biological fact of the division of labor, of specialization of parts, of the consequent interdependence and

reintegration of these parts furnishes a most striking parallel and picture of the social necessities, obligations, and limitations to which the youth must individually adjust himself. It emphasizes a social point of view which is well worth while.

In a word, the biological sciences furnish vital data concerning the philosophy of the educational process; furnish basal ideals of life for the individual; supply a large mass of material directly of use in the practical carrying out of these ideals; beside giving such discipline of certain aspects of personality as to contribute to the art of living. No subject can do more.

WHAT ARE THE PRACTICAL, PEDAGOGICAL AND SCIENTIFIC BASES FOR THE STUDY OF BIOLOGY IN SECONDARY SCHOOLS?

By Nathan A. Harvey,

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It seems to me that it is rather decidedly better to consider botany, zoölogy and physiology as separate subjects in high schools than to teach biology as a single subject. The reasons for this belief will be found in a consideration of the first part of the topic.

We may safely assume that all education is intended to lead to better processes of thinking, and that thinking consists in the perception of relations. All relations may possibly be reduced to a single general one, that of resemblance. In order to train a pupil to perceive relations, we must set him to perceiving them. We must furnish abundant opportunities for such exercise in cases where the difficulties are carefully graded, and we must not point out to him the relations that other people have discovered. He must be taught to perceive them himself, and his attention must be held upon the objects between which the relations exist until the relations have become manifest to him.

If we study animals or plants, which is perhaps a better designation of the subjects in high schools than is zoölogy and botany, we furnish to our students opportunities for perceiving a multitude of relations which we must neglect if we study biology, in the proper sense of the word. Every individual animal and plant is itself the center of correlation for a multitude of relations. Those relations which adapt it to its environment, and those which are derived from its inheritance, its taxonomic relations,

are likely to be omitted if biology is the proper designation for the subject studied.

If we study animals and plants, we naturally begin with the individual animal or plant. If we study biology, we do not necessarily begin with the individual, but more likely with the cell, or some other element of life. Science has its foundation in the study of the individual thing. The study of animals and plants leads us from particulars up to the general by successively higher and higher generalizations. Biology implies that we shall begin with the highest generalization already made, and perceive illustrations of that generalization by examining particular instances. This is the essential difference, as I see it, between the study of biology and the study of animals and plants. The study of animals begins with particulars and rises to generals. It is inductive in its nature. The study of biology begins with the general, and reaches to the particular. If we begin with the generalizations already made, we lose the opportunity for the student to make the generalizations himself, and this is the greatest opportunity for educational activity that science affords.

When a class of students really study animals and plants, it is easy to cultivate the attitude of mind that makes them carry forever with them a feeling of friendship and interest in the animals and plants which they study. If we study biology, in the proper sense of the word, we teach our pupils to see in the subject illustrations of laws expressing profound truths of philosophy, but we lose the feeling of affection and interest in the animals and plants which might be obtained. For persons who do not become professional biologists, the former attitude of mind is of enormously greater importance.

So for these reasons, that the study of animals and plants enables the teacher, with the same expenditure of energy, to furnish enormously greater opportunities for the perception of relations; that it furnishes to the pupils opportunities to make their own generalizations; that it begins where all scientific study ought to begin, with the individual; and that it inculcates a feeling of personal relationship with animals and plants, I should prefer to teach botany and zoölogy as separate subjects.

The above considerations may serve as a statement of the pedagogical bases for the study of biological subjects in school. They are necessary for the most economical attainment of skill

in employing the mental processes of abstraction, analysis, discrimination, comparison, classification and generalization; in other words, for attaining skill in thinking, or the perception of relations.

PURPOSES IN SECONDARY SCHOOL BIOLOGY.

By Henry B. Ward,

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It is difficult to separate the practical, pedagogical, and scientific bases for secondary school work in biology. Through the study of biology we obtain a knowledge of the principles of life which underlie all nature about us, which are the foundation of our own being, which give us the proper understanding of health and disease, of success and failure, of social relations and personal control. At the same time the laboratory training develops keenness of eye in seeing things as they really are, correctness of judgment in distinguishing between that which apparently happens and the real occurrences, in deducing proper conclusions from the facts which are presented, all of these things are of incalculable value for the individual in later life, whatever line of activity he may be called upon to follow. The most of the errors to which men in general are subject and the most of the difficulties into which they fall are due to inability to see correctly and to think clearly. Moreover in real life a man is not called upon to think in the abstruse but to observe everyday facts and draw from these concrete instances the proper conclusions. True biological study is more than book training. It is obtained by contact with nature and natural objects and consequently yields precisely the training which is most valuable in later life.

In my opinion it is rather immaterial whether the course be a general one, using both plant and animal material for developing the fundamental principles in order that the student may acquire some conception of life in its contrasted lines of development, or whether on the other hand, it should be an entirely distinct course in botany and zoölogy. In most cases that course will be best taught which follows the mental bent of the individual teacher and if the instructor be warned not to neglect the dual aspect through his overpowering interest in the one or the other side, it will be best to allow him the exercise of

his own preference in keeping the lines of study distinct or in combining them to reach his ideal biological study.

So far as work in human physiology is concerned, I feel that better results will be obtained by placing this alone in the last year of the secondary school course. In the first place there has been a rest from the legal grind and from the uninteresting and often deadening repetition of the required instruction in grammar grades, and there is also the possibility of discussing the subject from the advanced standpoint which a study of chemical, physical, and biological science has made possible.

PLANT ECONOMICS.

By Wilbur H. Wright,

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One of the criticisms more commonly made on our courses in high school botany is that they are "too scientific." The principals tell us that we are trying to imitate the college too much; those parents who try to be particularly practical often elect bookkeeping or stenography for their children instead of botany, and some of the pupils themselves, if they do not openly express their idea of a less utility of plant study, manifest it otherwise by occasional fits of indifference. Thus the parent and the child, although they may not be able to formulate their criticism as well as the principal, are often in agreement with him in their objection that the botanical courses lack sufficient contact with ordinary life.

The old idea of spending most of the time in the study of leaves, flowers, fruits, seeds and so forth and in making herbaria may not have been a well balanced or a scientific one, but it at least resulted in the acquaintance of the pupil with the plants that surround his daily walk in life and that is wherein many of our present courses are weak. This does not mean that our present efforts in physiology and ecology should be lessened. Plant physiology and its applications, as far as they may be brought out in secondary work, make such courses more valuable in this respect than the corresponding zoological studies. And although the late enthusiasm for ecology seems to have declined somewhat, ecological studies have come to stay, as is proper. But as a result of these tendencies and a much fuller treatment of the lower

forms, while the subject matter is beyond question much more complete than that of a generation ago, it has become too much isolated from the common life of the ordinary child. Not being able to realize its great philosophic value, and not seeing any broad areas of contact with his own life, he avoids it or takes it "for credit."

To counteract this, special emphasis must be placed on plant economics. We may thus demonstrate that very much that comes to us in life comes from plants and that problems of their products are life problems for both ourselves and the plant. Some of our best text books deal with occasional topics along this line. But the method of developing the real economic plant values may be open to question. It may be by mere discussion of such values in connection with the groups to which they belong. The discussions in lecture or recitation make both the laboratory work and text more vital through contact with human life. For instance, after studying lichens, to know that they may furnish food for reindeer in Norway increases the interest. To know that they may furnish the basis of an indicator valuable to chemists at home, with a simple demonstration of litmus, ought to increase it more, and the fact that they are important agents in corrosion of rocks in our door yards, most of all, because it deals with action in the child's own world. The phenomenon of symbiosis which would appeal to the botanist as of paramount importance may appeal to the pupil least of all. He does not feel that it really concerns him.

If this be the case the remedy appears plain. A sense of the practical importance of botany must be more generally developed in our courses and it may be most easily done by bringing in more work relating to our food, shelter and other of the endless economic phases found in our relations with plants. To do this, without overdoing it, will require certain concessions on the part of the demands for morphology, taxonomy and some other topics as usually treated. The economic phases will be often of a lesser importance from a scientific and philosophic view point. But if it makes the pupil think more about what he eats and wears and sees around him it will be of much more value than a broader biological metaphysics about which he does not think.

In order to do this, mere discussion is insufficient. These relations must be developed more fully as part of the laboratory

experience. And evidently since they are found in so many phases of plant study they must be correlated with them and any attempt to confine them to any special interval would be futile. Thus if we look for some of the broader points of contact, such topics as food, textiles, building materials, ornaments, relation to disease and health naturally suggest themselves. Evidently such a grouping of topics would cause confusion from a botanical standpoint and it would be better to take them individually under roots, stems, fruits, bacteria and so forth, as they occur naturally in the course.

Suppose we begin with "seeds." The above plan would suggest something like the following: Development of the economic importance of the seeds or grains of the bean, pea, corn, wheat, oat, barley, rye, broomcorn, cotton, coffee, cacao, nutmeg. These or their products alternate at breakfast, lunch and dinner throughout our lives. Does botany as usually presented develop an intelligent interest in them?

After studying the bean, castor-bean and pea seeds and the corn grain in the usual way, including germination and microscopic examination of typical starch grains and tests for sugar, proteids and oil, tables showing percentages of these substances present and the values of these should be discussed. For these. except the castor bean, see Leach, Food Inspection and Analysis (Jno. Wiley and Sons '04) p. 212 et seq.

Flax seeds, wheat, millet, oat, barley, and rice grains and buckwheat achenes should now be described, at least with regard to external characters and a microscopic examination of at least the oat starch made. It is convenient to study that of the potato here also. Tables may now be furnished showing the principal constituents present in most of these and their values. Samples of ordinary wheat flour, graham flour, corn meal, oat meal, bran and buckwheat flour may now be examined as to taste and appearance and tests made by alternate portions of the class for starch, sugar, oil, proteids and cellulose (Leach, p. 236, and Farmers Bulletin, Department of Agriculture, 142 p. 14 and 17). An exhibition set of corn products is useful here. A microscopic examination of material sold as corn starch (for cooking) and of laundry starch should be made and the origin of the two recorded. Discuss starch adulteration and its detection. Prepared breakfast foods naturally come next and a few typical ones should be examined at

least macroscopically, with a discussion of their origin and value. Quaker oats, puffed rice, Pettijohn's and corn flakes are suggested and a comparative microscopic examination of these is worth while. In addition to castor oil, mentioned before, linseed and cottonseed oils should be furnished and their values discussed and those of beans and peas as nitrogenous foods tabulated. Cotton seeds and cotton fibre may be exhibited and essay work on this textile assigned. Nutmeg seeds may be passed around and the flavors tested. A somewhat fuller treatment of coffee is of interest. The following has been used: State the differences observable between the samples furnished (Mocha, Java, Brazil, green and roasted, etc.) Describe and draw one seed. Boil a little ground coffee in water in a test tube. Extract a second portion with ether. Note the foreign matter present in adulterated samples furnished and the rapidity with which some samples color water. A positive starch reaction also shows adulteration. Note the artificial glaze on some samples. Obtain your material for an essay, from some reference work, on the following: description of the coffee plant and its fruit, areas of production, methods of curing; caffeine, its occurrence, properties and physiological effects; historical statements.

Further topics for study and references on cereals, their cultivation, breeding and relation to wild plants (illustrated by herbarium specimens or lantern slides), milling methods, bird food, cacao, Tonqua beans and so forth, relating to the foregoing may now be assigned for essay work and a tabulation made of the products concerned, which are used at home. Some of the well known medicinal values of seeds as exemplified in the mustard and flax seed plasters, castor oil and strychnia should be discussed. It may be more convenient to study types like the Brazil nut with fruits. The relation of the Department of Agriculture to seeds and seed distribution should be made clear and some bulletins examined. The testing of some different grades of commercial seeds and tabulation of the results showing percentages of germination is valuable.

Work of this kind which makes the pupil think for himself and leads him to observe and speak of his work at home cannot but vitalize the subject for the ninety and five who are not preparing to enter college. Does the average pupil really understand the connection between botany and his own breakfast? Has he any idea of the comparative values of seed products? Is

it of less utility to know the value of these products to man than to the plant?

In the study of stems the external characteristics and the internal structures of typical dicotyledon and monocotyledon stems and modifications due to special conditions of physiology and ecology are commonly studied. An attempt to bring this work into a broader contact with outside experience would naturally suggest something like the following topics: lumber, wood products, paper, resin, turpentine, gums, stem foods, ornamental stems medicinal values. In studying lumber, after median and tangential longitudinal, and cross sections have been studied it is well to begin with the top and sides of the laboratory table, book shelves, cases and floors. Samples of various woods polished on one side come next and a few specimens should be tested as to comparative hardness and weight. The assignment of tabulated reports on the character of furniture and its origin stimulates observation at home and the pupil often sees oak, pine or bird's eye maple in his own chair for the first time.

In connection with turpentine and resin, samples of gum arabic, gum tragacanth, cherry gum, Canada balsam, camphor, rubber, amber and varnish should be examined. Essay work on the resins, gums, gum resins and other extractives and their uses in daily life will necessarily vitalize the study. How many pupils realize that there is any vital connection between plant life and their chewing gum, erasers, rubbers, mucilage, pills and varnished table, or the contents of the camphor bottle? And mere words are insufficient. A minute spent in examining a gum itself will reënforce the idea more than a long discussion of something which they have never seen. In dealing with the topic of paper, various qualities may be examined, essays read on its manufacture and on the forestry problems related to it. The work of the Forestry Bureau should be emphasized. This may be done by assigning some of the bulletins for use on Arbor day. This suggests the identification, somewhere in the course, of a few common trees. Is the average pupil, after spending a year in botany, able to recognize twenty-five trees with certainty? Many of them do not know five, because it is easier for the teacher to bring algae into the laboratory than to take the class out to the trees.

The large part that stems play fron an esthetic point of view will have been developed in studies of stem modifications.

Some of the more striking types like birch bark, twigs of the golden osier and red stemmed cornel should be brought in for this purpose. The values of stems as food for man and beast may be emphasized partly by mere mention. The potato and asparagus should be studied.

The use of corn stalks for fodder should be considered. An exhibition of corn products (partly stem) has been alluded to above. This will introduce the topic of textiles and specimens of flax plants should be furnished. Linen goods may be examined with and without magnification and several tests helpful in distinguishing linen from cotton demonstrated. Hemp, flax, Manila, jute and ramie fibers, bags and cordage exhibits and bamboo are useful in this connection. Cork, quinine, witch hazel and cinnamon should be taken up and such vegetable dyes as logwood, quercitron, Brazil wood, along with galls and their relation to ink.

In the study of the structure and modification of roots such forms as the sweet potato, beet, turnip, parsnip, carrot, radish and horse-radish will usually be included. Sassafras tea, ipecac, sarsaparilla and licorice extracts will be familiar to many. If the laboratory can afford it, a taste of ginseng root, similar to that formerly worth its weight in gold in Pekin, often excites a greater interest in roots of more real medicinal worth. Madder root and its contained dye furnishes an example of other root uses.

The beauty of leaves and foliage masses will appeal to many. Lantern slides or park studies in landscape gardening and yard decoration offer a phase of much needed municipal improvement. Ferns, palms, evergreens, autumn leaves and decorative foliage plants such as Coleus and the rubber plant impress some children more than flowers. A more prosaic but first hand acquaintance with leaf uses comes out in discussing dandelion "greens," spinach, cabbage, onions, lettuce, parsley and tea. Since these products are matters of common experience discussion without special examination may be sufficient, if the time is limited. In connection with medicinal values boneset, wintergreen, horehound, peppermint, pennyroyal, bay rum and eucalyptus will furnish some examples of more or less familiar drugs extracted, at least in part, from leaves.

The use of clover, timothy hay and alfalfa should be discussed either here or under stems, and herbarium specimens shown.

The sugars, like some of the foregoing, illustrate the fact that many products may be taken up in either of several connections. It would seem logical to treat them under roots, stems, leaves, fruits or seeds. In spite of this manifold opportunity classes often emphasize only their relation to other carbohydrates. Many pupils finish botany without knowingly having seen and tasted glucose. It would seem that the origin, uses to plant and man, the food value and something concerning the refining industry ought to be included.

The study of flowers furnishes another example of the fact that many botanical courses conform too much to a philosophic standard rather than to values based on experience in life and the home. For usually the representative wild flowers of the important groups are studied to the exclusion of the carnation, the begonia and other cultivated house plants. The house geranium may be less interesting in itself than the orchid but the average pupil has to live with it. It would seem reasonable in this connection to tabulate the most familiar home grown plants, to indicate their relationships, peculiarities the best methods of caring for them and to have them around in the laboratory as a matter of course. A talk on floral perfumes and their extraction is well worth while and may be prefaced by having the class obtain a list of toilet waters, colognes and perfumes exhibited in the drug stores. An examination of cauliflower and cloves should be made in this connection to illustrate other than aesthetic uses.

Although the flower and leaf modifications may excite more interest than most others on account of their beauty, the topic of fruits is second to none in its breadth of contact with ordinary experience. In studying the important types of fruits many of the varieties found on the table will naturally be included. After such type study is finished, emphasis may well be placed on the remaining familiar forms like the winged maple "seeds," and table fruits. I believe that an attempt should be made to examine and discuss the following if they have not been already included in the preliminary examination of the typical forms: legumes, grains, acorns, chestnuts, citrus fruits, gooseberry, currant, grape, Capsicum, tomato, banana, apple, pear, cucumber, pumpkin, squash, peach, plum, prune, cherry, olive, walnut, cocoanut (the products of which should be clearly differentiated from cacao). Since there are so many fruits to be examined it may be necessary to have the pupil report on important types

only and to have a lecture and demonstration of structure of the remainder by the instructor. This saves both time and expense. Of course for material that comes into the market at an inopportune time preservative must be used or the structure illustrated by charts. Tables of the constituents and value of some important types should be furnished, (see Bulletin 142, cited above, page 18 and 28) and a comparison made with seeds.

The average class can give expert evidence as to the kinds of flavors used at the soda fountain and many of them come in here. Discrimination is necessary here, as for instance in the case of the orange where the pulp and juice are often used in ices, the oil obtained from the rind figures in various confections and orange water from the flower is used for other purposes. At this point lists indicating sources of perfumes, medicines, flavoring extracts, and other economic phases as indicated above should be made as complete as possible, by comparison of individual lists.

If we examine the thallophytes in the same way in an endeavor to find some pegs of experience on which to hang further knowledge, we discover that their relations to us are distinctly different. How many green or blue green algae will the pupil have used for food or clothing? Or how many brown or red algae has the average inland pupil ever even seen? And since these forms are not matters of common experience and conversation the phases of life relating to them are likely soon to be forgotten. Of course it is not difficult to compile a list of instances in which the lower forms play an important part in our lives. This is especially true of the fungi and some of these instances should be dealt with. But as compared with seed plants and excepting the bacteria, moulds, and yeasts, most of them are not so commonly experienced in home and business life and are therefore less valuable for our purpose. And while enough of the simpler types should be included to develop some of the fundamentals of physiology, ecology and evolution it would seem reasonable to emphasize these less and the spermatophytes more. In this connection botany needs perhaps to be saved from the hands of its friends who are trying to make our secondary schools into little universities.

We may summarize the foregoing as follows:

1. Our botany courses are often criticized as being "too scientific" and these criticisms come from sources deserving of consideration.

2. The remedy lies in developing as much of the practical side as possible.

3. Economic problems relating to seeds, stems, leaves, flowers, fruits and some of the lower forms are life problems for both ourselves and the plant and should be more fully developed than they usually are.

4. Many of the lower forms are not connected with our ordinary experience and they should be emphasized less.

5. In general the course should be based on the idea of utility to the pupil, rather than upon a broad philosophy of plant life.

VELOCITY OF SOUND IN SOLIDS.

By R. M. Barrus,

Keuka College, Keuka Park, N. Y.

In answer to requests for explanation of the method used in our laboratory to determine the velocity of sound in solids, I give the following:

Materials required: Tuning fork. C,″ Small adjustable iron vice. Bench or board at least eight feet long, arranged for attaching the vice anywhere along the edge. About three metres each of wires of different materials.

The pitch of a tone produced by longitudinal vibrations does not depend upon the tension or the diameter of the wire, hence any common size and sufficient tension to hold the wire straight will answer the purpose.

Fasten a wire securely at one end of the bench or board and secure the other end of the wire with the vice in order to vary the length. Stroke the wire lengthwise with a small cloth well dusted with resin by pinching the wire lightly in the cloth with the fingers. This will cause the wire to give a loud tone from its longitudinal vibrations. By varying the length of the wire carefully determine the exact length necessary to give a tone having the same pitch (number of vibrations per second) that the tuning fork, C″ has.

C″ has 1024 vibrations per second. 342.5 m is the velocity of sound in air; therefore 332.5 divided by 1024 equals the length of each vibration, that is the distance between condensations in air, .3246 m. This bears the same ratio to the distance between the condensations in the material as velocity in air bears to velocity in the material. Double the length of the wire is the distance be-

tween condensations in the material, because the mass makes a complete or double vibration for each condensation sent forward, therefore;

Length of wire multiplied by two is to the length of air wave as velocity in wire is to velocity in air.

Piano wire giving same tone as fork C″ measures 2.495 m, then 4.99 : .3246 :: X : 332.5. Whence X equals 5112 m, the velocity in piano wire iron.

Apply same process to find velocity in other materials.

Note—To consider the influence of temperature upon velocity of sound in different materials requires the application of Newton's formula that velocity varies directly as the square root of the coefficient of elasticity and inversely as the square root of the density of the medium.

Approximate method: A small rod of the material to be tested, two or three metres in length and 2/10 to 6/10 cm. in diameter.

Hold the rod at its center and stroke towards one end with resined cloth and secure a tone from longitudinal vibrations. Find the tone of a piano which has the same pitch as the tone produced by the rod. Use the number of vibrations of such piano tone in the above proportion in place of the number of vibrations of C,″ also double the length of the rod. This will give approximate velocity of sound in the material of the rod.

110 VOLT ALTERNATING CURRENT FOR BELLS.

By L. A. Robinson,

Oregon State Normal School, Monmouth.

In practice we have found the 60 cycle alternating electric light current quite successful for our school signal bells, thus saving the trouble and expense of a large battery for the system. The 15 bells are connected in series and each bell is short circuited across the interrupter contact with a small piece of wire. The bell circuit which is a part of the electric light circuit includes in it a 32 c. p. lamp used as a resistance, and is connected and disconnected by a telegraphic relay instrument. The relay is connected with the signal clock and worked by a small dry cell. Thus the clock controls the relay and through it the whole system of bells. Some form of resistance is necessary, and for a system of 15 bells the 32 c. p. lamp gives satisfactory results.

THE SUN-PATH DIAL.

By Joseph F. Morse,
Medill High School, Chicago.

The Sun-Path Dial is an adjustable device for demonstrating the course of the sun above and below the horizon of different latitudes at different times of the year.

It consists (see Fig. 1) of a meridian circle with a rotating piece, carrying the equinox and solstice sun-paths—appearing as lines because viewed edgewise—pivoted to its center.

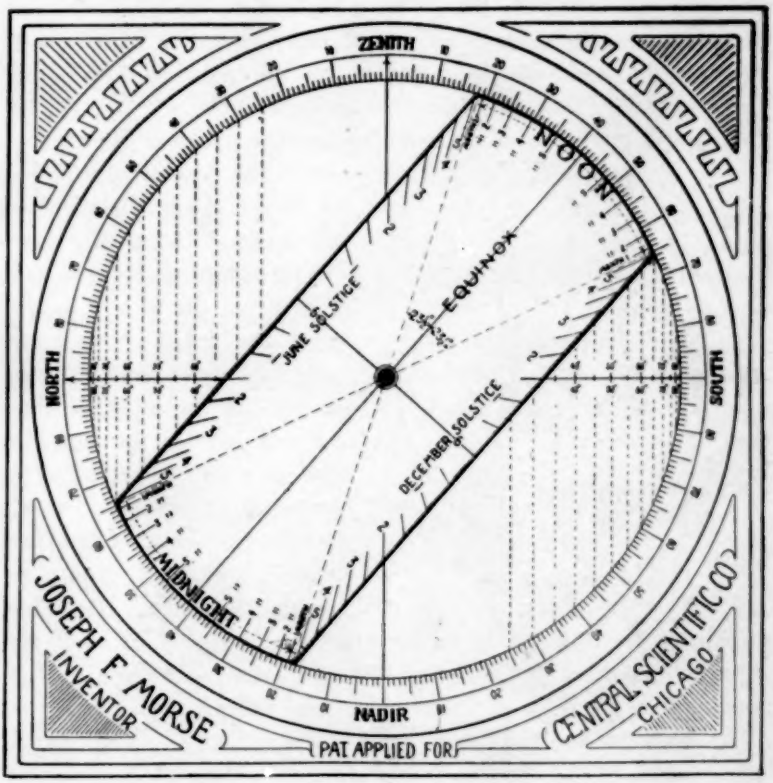

FIGURE 1.

Supposed observer of sun is at center of dial. His horizon circle also appears as a line because viewed edgewise.

The Sun-Path Dial originated as a *side-view* of the *Heliodon*, or sun-path model—described in a former issue of School Science and Mathematics (June, 1906). The model consists of a horizon *disc* encircled by equinox and solstice sun-path *rings*. In the Dial the disc and rings appear as *lines* because they are

represented as viewed *edgewise*—from due west of observer at center of disc.

The Dial may also be thought of as a projection of observer's horizon circle and equinox and solstice sun-paths upon his meridian plane, the projection being viewed from the west.

The Sun-Path Dial is designed for use by pupils in "laboratory" work. By manipulating the Dial, under the guidance of questions furnished by the teacher, the pupil can study out for himself the facts of insolation. He can verify and supplement his observations of the sun at his own latitude, and find out and picture to himself—by pointing successively in the direction of sunrise, the noon sun, and sunset, as given by the Dial—the sun's course as viewed from other latitudes.

Suppose pupil begins his study of the sun-paths at Quito. To adjust for equator he places the rotating piece vertical to the horizon (see Fig. 2). The days and nights are seen to be equal the year through, since the solstice sun-paths (edges of the rotating piece) as well as the equinox line, are bisected by the horizon. The noon sun is shown to be overhead at equinox, 23½° north of the zenith at the June solstice, and 23½° south of the zenith at the December solstice. In this—as in every other—adjustment of Dial the equinox sun rises due east and sets due west. The June solstice sun crosses the horizon, in its rising and setting, 23½° north of east and west, and the December solstice sun 23½° to the south. By imagining one solstice line shifted slowly to the position of the other and back again the pupil can picture the complete course of the sun during the year as viewed from the equator.

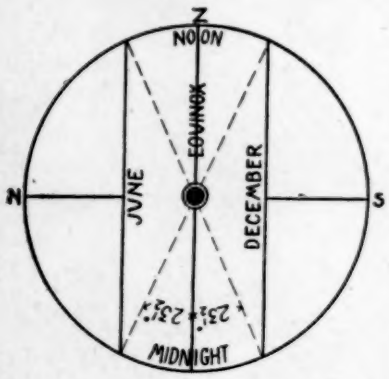

FIGURE 2.

If pupil imagines himself traveling northward from the equator he leans the noon end of the rotating piece southward from the vertical position as many degrees as he goes, gauging by the equinox line. As he does so he will see: (1) that the eqinox line continues to be bisected by the horizon—by construction of

Dial; (2) that the mid-summer days and mid-winter nights grow longer, at an equal rate—the June edge of the rotating piece being thrown more and more above the horizon and the December edge below it; (3) that the rising and setting points of the solstice sun retreat from the east and west, the June sun northward and the December sun southward.

Figure 1 shows the adjustment for 41½° north latitude—say Cleveland. The equinox noon sun is 41½° south of the zenith —by adjustment. The mid-summer sun is 18° from the zenith (41½° minus 23½°), and the mid-winter sun 65° from zenith (41½° plus 23½°). The solstice sun crosses the horizon about 32½° from the east and west, the summer sun to the north and the winter sun to the south. The length of solstice days and nights can be read from the time marks—one half-hour apart—along the edges of the rotating piece. The adjustment for Cleveland throws the June end of the 6 o'clock line three half-hours above the horizon and the December end an equal distance below it. The June solstice days are thus seen to be 15 hours long—the sun rising 3 half-hours before 6, at 4:30, and setting 3 half-hours after 6 at 7:30—and the December solstics days 9 hours long, 6 o'clock, morning and evening, being 3 half-hours below the horizon.

To fix on his own horizon the places of solstice sunrise and sunset given by the Dial, the pupil may temporarily convert the meridian circle into a horizon circle by holding the Dial horizontal with the zenith point to the east. A pencil held to connect the center of the Dial successively with the proper points on the circumference will point for the pupil in the directions of solstice sunrise and sunset. The dotted lines crossing the horizon line at right angles (see Fig. 1) are to guide the pupil in projecting upon the extemporized horizon circle the points of solstice sunrise and sunset given by the Dial.

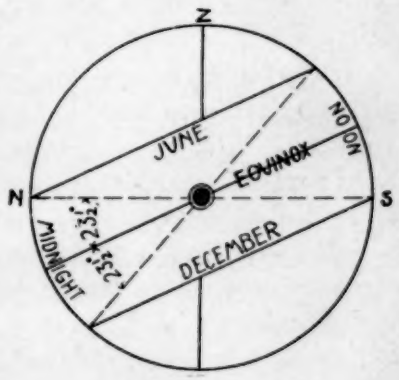

FIGURE 3.

In the adjustment for the Arctic Circle—as Iceland—(see Fig. 3) the June edge of the rotating piece just touches the

horizon from above, and the December edge from below—showing a 24-hour day, with the midnight sun on the northern horizon, in midsummer, and a 24-hour night with the noon sun on the southern horizon in midwinter.

Beyond the Arctic Circle the edges of the rotating piece are thrown farther and farther from the horizon, above and below, indicating an increasing period of continuous sunshine in summer and continuous night in winter. By means of month marks along the ends of the rotating piece (shown in Fig. 1) pupil can note the latitudes at which the sun is continuously above the horizon in summer and continuously below it in winter for 1, 2, 3, 4, or 5 months.

At the north pole the sun-paths are parallel with the horizon (Fig. 4) with the equinox sun on the horizon all day, the June solstice sun 23½° above, and the December soistice sun 23½° below. It takes 6 months for the sun to wind its way up from the horizon to the June position and back to horizon again, and 6 months to sink to the December position and return to horizon.

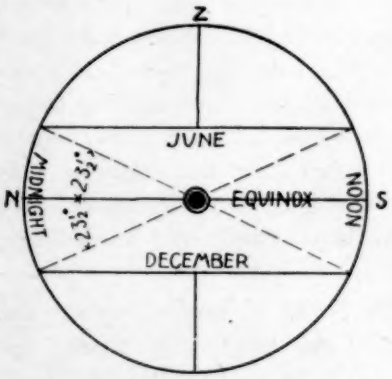

FIGURE 4.

Should pupil travel southward in thought from the equator, he leans the noon end of the rotating piece northward as he goes. This throws the December edge more and more above the horizon and the June edge below it. At the same time the December noon sun is brought nearer the zenith than the June sun. With long days and a high sun in December and short days and a low sun in June the seasons are reversed. The rising and setting points of the solstice sun retreat from the east and west, as when pupil traveled northward, the June sun, as before, crossing the horizon more and more to the north, and the December sun to the south.

In every adjustment the Dial shows the position of the midnight sun—how many degrees it is above or below the horizon, and in what direction.

The length of summer and winter twilight at any latitude can be read from Dial by holding a ruler edge parallel with the horizon and 18° below it and counting the half-hour spaces intercepted between the horizon and the ruler.

The latitude required for any given length of solstice day may be determined from the Dial. Suppose pupil wishes to know at what latitude there is a 20-hour day in midsummer. He inclines the rotating piece until he has thrown 6 o'clock, morning and evening, 4 hours above the horizon, and reads the latitude by noting how many degrees from the zenith the noon end of the equinox line is.

In a similar way the pupil can find the latitude at which the solstice sun rises and sets a given number of degrees—say 60°—from the east and west. The edges of the rotating piece are so placed as to cross the horizon line at 60°, and the latitude read as before.

The Dial may be used to demonstrate the decreasing intensity of slanting sun's rays. For this purpose the rotating piece would represent a shaft of sunlight, which covers more or less horizontal surface (the horizon line) according to its slant. By means of the meridian circle the beam of light can be placed at any angle to the horizontal. Sunshine intensities at different slants can be compared with each other and with vertical sunshine by measuring and comparing the portions of the horizon line covered by the rotating piece in its different positions.

Astronomy pupils can locate the celestial poles for any latitude by extending the 6 o'clock line of Dial to the meridian circle with a ruler edge. The equinox line fixes the position of the celestial equator.

It will be seen from the foregoing description that the Sun-Path Dial shows *how* the sun's course varies with latitude, but not *why*. The Dial is not designed to displace globes and tellurians in the study of seasons, but to supplement them. The usual globe demonstration of seasons views the earth and sun from *space*, leaving the sun's course as seen from different latitudes to be calculated. The Dial pictures the sun throughout as *viewed from the earth*.

APPARATUS FOR INSTRUCTION IN GEOGRAPHY AND STRUCTURAL GEOLOGY.

PROFESSOR WILLIAM H. HOBBS,

University of Michigan.

I. MAP CONTOURS.

Until the student has become familiar with the idea and use of surface contours as employed on hypsometric maps, a very large part of the field of physiography remains closed to him. He is in the position of the student of music who is unfamiliar with musical notation. Thus in a strict sense he is debarred from making use of the great reference libraries of physiography—the topographic atlas sheets—until he has acquired the language in which they are printed. Some students, and those especially who possess what the Germans term *Vorstellungsgabe* and we *visualizing power,* move rapidly toward an intelligent use of the map. Others will require every aid which can be afforded them before the grammar even of the subject is acquired. For many it will only be necessary to read with care the excellent and remarkably clear statements concerning the manner in which contours express elevation which appear upon the inside of the covers of the United States Geologic Folios. Obviously it is not for such students that the aids hereafter to be described were especially designed, though it is thought that even for them individual laboratory study with the apparatus will be of distinct advantage.

A topographic contour map being always an approximation only to a correct representation of the configuration of the country, it may be described in terms (1) of the measure in which it assumes to approach a correct delineation, and (2) the measure of warrant for the degree of correctness assumed. These contrasted ideas are embodied in the terms precision and accuracy. The measure of precision is afforded by the map in its scale and in its contour interval. A map printed on the scale of two inches to the mile and with a contour interval of ten feet, makes larger assumptions than one printed on the scale of two miles to the inch and with a contour interval of one hundred feet. Though more precise the former may, however, be no more accurate than the latter. Assuming, however, that the map was intelligently, skillfully, and conscientiously made, its accuracy will depend chiefly

on how many points there are upon the map whose position and elevation have been determined, since these are the basis upon which the contours have been sketched.

In the case of the most accurate of contour maps, the engineer by means of his transit locates and fixes the altitude of a very large number of points. He then notes at each of these, or at such points as seem necessary for his purpose the direction and the angle of the slope. Contour lines, representing as they do points on the same level, are horizontal and therefore at right angles to the directions of slope. The map maker's task is therefore completed by drawing his contour lines perpendicular to the lines of steepest slope, and at such distances from the points located as the altitudes and angles of slope at each of the latter require. The simple model and exercise which are to be described aim to put the student in the position of the engineer who makes the map, and, when the work has been completed, to apply a simple test of its accuracy from the use of which the actual map maker is debarred.

The apparatus for the purpose consists of a box of galvanized iron one foot square upon the bottom and five inches in depth

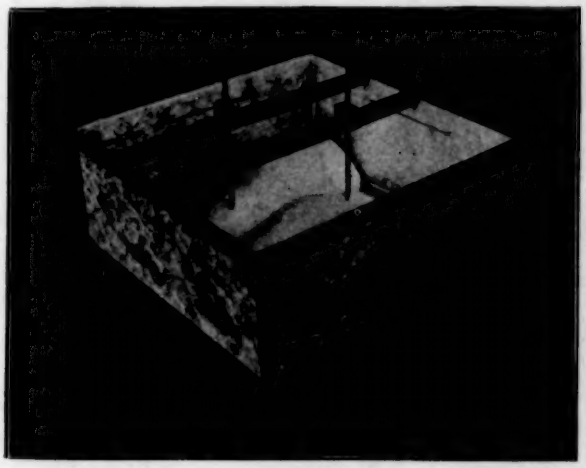

Fig. 1.—An apparatus for instruction in the use of map contours.

(See Fig. 1) with a ¾ inch flange or rim at the top. On each of two opposite sides this rim is provided with a row of stout iron pegs ⅛ inch in diameter and ⅜ inch in height, and these are set

one inch apart with the terminal pegs in each row ½ inch in from the side walls of the box. The box is further provided with a small brass faucet set at one corner and low enough to empty it of water to within ½ inch of the bottom. Four inches above the bottom, a narrow stripe is painted on all four sides so as to allow of bringing the box to a level position when largely filled with water. There is, further, on one side a series of narrow stripes at half inch intervals extending downward to the bottom. This gauge is to permit of withdrawing the water from the uppermost level in successive half-inch layers.

An attachment to the box is a stiffened brass strip one inch in width perforated at each end and of just such length as to stretch across the top of the box from the peg on one rim to the corresponding one upon the other. This strip, except at the ends where it overlies the flange of the box, is divided lengthwise by a slot. It is further graduated into half-inch intervals and provided with a sliding carriage supporting loosely a vertical rod pointed below and, like the strip itself, graduated into half-inch intervals (See Fig. 2). The sliding of the carriage along the strip, and the movement of the rod upward or downward through its carriage together permit of bringing the point of the rod to any point in the middle vertical plane of the strip. The transfer of the strip successively from one pair of pegs to each of the others further permits of reaching all points in a series of near-lying, parallel, vertical planes, and thus, so far as is necessary for our purpose, we may locate the position and fix the altitude of any point within the box. The vertical rod is so graduated that when the point rests upon the bottom of the box, the reading is zero. This is the datum plane corresponding to sea level or any other assumed datum. The figures corresponding to successive half-inch elevations of the rod from the floor of the box are in order, 1, 2, 3, 4, etc.

Fig. 2.—The sliding carriage and the vertical measuring rod.

Models constructed of plaster of paris to represent a portion of the earth's surface, are made of such size as to fit easily within the box. It is well that these be of quite simple character; such, for example, as a volcanic cone, a pair of drumlins, or a simple area of mature erosional topogra-

phy. To prepare these models a form is first made in artist's modeling clay. This is covered with strips of cotton sheeting, and plaster of paris put on a thin coat in order to form a mold, from which, when hard, models may be cast in the numbers needed for class work. The casts are smooth and coated with oil or vaseline in order to keep out the water.

To prepare a topographic map of any desired model, the latter is placed on the floor of the box and the measuring attachment to the apparatus is fixed in position upon a pair of pegs which will allow the point of the measuring rod to describe a section across one of the margins of the model. Measurements

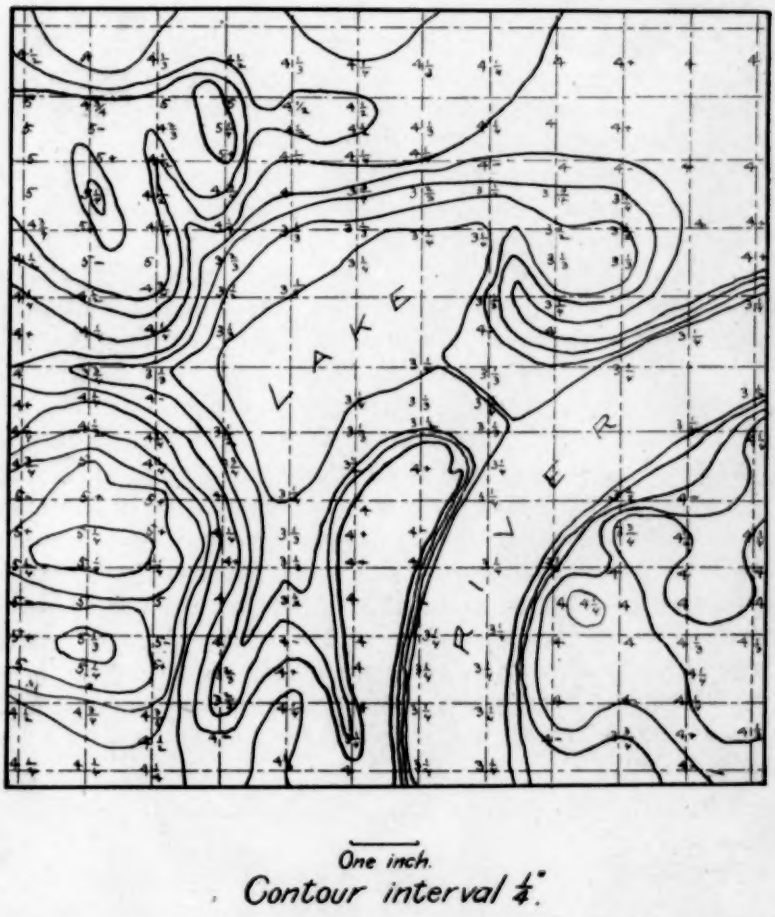

Fig. 3.—A student's map on section paper of a simple model of low relief.

are now made successively at half-inch intervals along this first section and the readings recorded at corresponding intervals on cross section paper. The direction of slope and its amount may be taken with a small clinometer compass at each observing point or as often as is deemed necessary, the direction being either taken accurately with the compass or estimated with the eye in reference to the sides of the tank. For this purpose it is necessary that the apparatus be oriented so that its sides correspond to the cardinal directions. One section completed, the attachment is moved to the next succeeding row of pegs where a similar process is carried out, and so on successively until all sections have been covered.

With the model still before him the student now begins drawing the contours (see Fig. 3). After such corrections as the instructor can suggest have been made, the box is filled with water to the level of the uppermost stripe. This water is now drawn off in successive half-inch layers, and each contour of the map in turn compared with the temporary shore line of the model to which it should correspond.

The association of a definite form of model with each map which the student prepares, tends to supply the form element to the map in a way not possible where no similar comprehensive view of surface form is obtained. The section paper used in the exercises is better chosen with a unit other than one inch, so that the idea of map scale may be gained at the outset through a comparison of this unit with the inch standard of the apparatus. If alternate contours be first drawn in, the comparison of this map with the completed one will show how the shortest contour interval adds detail to the map. Each apparatus may, if desired, be provided with two measuring attachments and so made available for use at one time by a group of four students, two of whom record the measurements while the others observe. Thus provided with two attachments and exclusive of the plaster models, the apparatus may be constructed in lots of six at a cost of three dollars each.

SOME QUESTIONABLE TERMS AND DEFINITIONS USED IN ELEMENTARY MATHEMATICS.*

By G. A. Miller,

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The mathematics of the high school is generally studied by means of text-books each of which bears one of the following titles, arithmetic, algebra, geometry or trigonometry. Just what these terms mean is difficult to determine and the more one advances in mathematics the greater this difficulty appears to become in view of the facts that many of the more advanced developments involve elements which belong to more than one of these subjects and that these subjects have no generally accepted limits. As evidence of this difficulty we may cite the fact that the "International catalogue of scientific literature" classifies determinants under algebra while the best mathematical encyclopedia, which is now appearing in parts under the title, "Encyclopédie des sciences Mathématiques," classifies the same subject under arithmetic. Hence two of the highest mathematical authorities in the world disagree as to whether determinants are a part of algebra or a part of arithmetic.

The fact that two such eminent authorities differ in their interpretation of the meaning of the terms arithmetic and algebra presents less difficulty than the apparent contradiction in the definition and use of the term arithmetic in one of these works. On page 21 of the encyclopedia cited above the following definition may be found: "The science of the relations which exist between numbers is *arithmetic*." On the other hand it is announced that the last section of arithmetic in this work is to be devoted to abstract groups in accord with the German encyclopedia upon which it is based. It is difficult to comprehend on what ground the theory of abstract groups could be classed with the relations which exist between numbers in the ordinary sense. This is the more remarkable since the theory of numbers is not classed under arithmetic but is developed in a separate volume of this encyclopedia and under a distinct title. If the comprehensive definition of arithmetic cited above were to be construed broadly it would evidently include a great part of the

*Read before the mathematical section of the High and Normal School Association, May 16, 1908, as a continuation of the paper published in School Science and Mathematics April, 1908.

mathematics which is now generally classed under other headings.

Instead of trying to define such terms as arithmetic, algebra, geometry, and trigonometry we may regard them as practically meaningless symbols which are placed on four different boxes in which we agree to store all of our earlier mathematical methods and results as well as many of the later ones. From this standpoint the term arithmetic, for instance, will acquire additional meaning with every new fact or method stored in the box bearing this symbol and as no two students are apt to have exactly the same things in their boxes marked arithmetic their conceptions of the meaning of this term are likely to be different, and these conceptions must vary widely from the one held by the profound scholar of higher arithmetic. In support of this statement it may be well to quote another sentence from the encyclopedia mentioned in the preceding paragraph; viz.: "It is customary, in arithmetic, to represent an arbitrary number by a letter, it being understood that this letter represents the same number during the same discussion." In accord with our early training most of us would doubtless have concluded that the representation of numbers by letters belonged to algebra rather than to arithmetic.

Possibly there is greater uniformity as regards the use of the term geometry than as regards those of arithmetic and algebra, but if any one should be desirous of formulating a definition of geometry in accord with the usage among the foremost mathematicians he would doubtless be greatly embarrassed by the fact that the Paris Academy of Sciences uses the term geometry as a synonym for pure mathematics and offers its prizes relating to all the various fields of pure mathematics under the heading geometry. Moreover the difficulty of formulating a satisfactory definition of geometry is increased by the fact that some regard it as an experimental science "independent of mathematics, just as psychology is gradually being recognized as an independent science and not as a branch of philosophy."* According to one of these views geometry is independent of pure mathematics while, according to the other, it is all of pure mathematics. It would appear impossible to embody such diverse views in a definition of the term geometry.

*Bocher, Bulletin of the American Mathematical Society, Vol. II, (1904), p. 12.

From the preceding considerations it is clear that the terms used to classify the mathematics of the high school have no generally accepted definitions. Nor is this surprising if we consider the interdependence of the various mathematical truths. Where facts are so interwoven and generally only very imperfectly comprehended it would be surprising if universally accepted lines of division could be established, especially as long as new relations and new truths have continually to be dealt with. If the mathematicians are compelled to use these terms in a somewhat vague manner it seems to be so much the more true that the beginners have to use them in such a way. This, however, does not mean that it is undesirable to point out the elements which appear most prominent in these various subjects. In fact, such broad view points are most desirable even if it must be admitted that they express partial truths. If we were inclined to say, for instance, that algebra deals primarily with equations we would be confronted with the fact that in the best encyclopedia of elementary mathematics, viz., "Encyklopædie der Elementar-Mathematik von Weber und Wellstein," the simple and the quadratic equations are classed with arithmetic.

The lack of uniformity in the use and definitions of the terms employed in classifying elementary mathematics is, however, not of prime importance to the student. The main attention should be fixed upon the theorems and methods which will serve as powerful instruments in his intellectual development. We have called attention to the uncertainty in definitions of these terms mainly for the sake of emphasizing the fact that definitions must frequently be preceded by extensive developments and may have practically no meaning until these developments are thoroughly understood. Moreover, it may be desirable to use the same term with different meanings as the student's knowledge advances. For instance, the term multiplication may first be defined as standing for a process which is simply a special kind of addition; *i. e.*, addition when the addends are all equal to each other. This definition should be enlarged when it becomes necessary to multiply by fractions, negative, and complex numbers. The advanced student will have to change his concept of multiplication again when he studies the product of matrices, group operators, and modular systems. It may appear unfortunate that we cannot give a definition in the beginning to

cover all these cases and still have a definite and clear meaning to the beginner, but such vagaries as "multiplication is the process of performing upon one of two given numbers the same operation as may be performed upon unity to get the other" seem to have very little value.

While the term multiplication is used much more consistently than the term arithmetic yet the different elements which enter into its various uses seem to be sufficiently diverse to regard it partly as a term of classification of related processes. The emphasis should be placed upon a clear exposition of the various processes rather than upon any justification for calling them by the same name. As quite different operations may belong to arithmetic so varied processes may be classed under multiplication. It must, however, be admitted that as far as possible each term should have but one meaning in mathematics but if this procedure were universally adopted it would involve the use of many new terms, and it is a question whether this would not be a greater evil than the use of terms which apply to classes of related things. The latter seems, however, to preclude complete definitions of some terms and may call for different definitions when the term is used for somewhat different processes.

As an instance where separate terms are used for special cases we may refer to the use of positive, negative, and amplitude in regard to numbers. When the amplitude of a number is o we say that the number is positive and when this amplitude is π we call the number negative. Perhaps these special terms are justified by the fact that numbers with zero and π amplitudes occur more frequently than those which have other amplitudes but they have also the disadvantage that the student is apt to forget to associate amplitude with the terms positive and negative, and to regard these terms as expressing properties unrelated to those expressed by other terms. For instance, the common rule for adding a positive and a negative number is included in the following: To find the sum of two numbers whose amplitudes differ by π take the difference of their absolute values and attach the amplitude of the one which has the larger absolute value. The terms positive and negative are so extensively used that it seems improbable that they will ever be changed, yet it might be desirable in theoretic discussions

to replace these terms by others which would exhibit that they stand for special amplitudes of numbers. The terms o—numbers and π— numbers have been suggested for this purpose.

The term graph has become very popular in recent times and is frequently used in a very vague manner. I need only refer to such directions as "Plotting these points and drawing a smooth curve through them, we have the graph of the equation." While I do not wish to criticise such directions yet it would perhaps be well to make an explicit statement of the fact that a smooth curve can be drawn through a finite number of points in an infinite number of ways and that we have no right to assume that the curve of an equation is smooth without proving that it has this property. It seems to have become popular to strain out gnats when we talk about axioms and to swallow elephants when we talk about graphs in elementary algebra. If this is good pedagogy it appears to me to be still better pedagogy to tell the student that the construction of a graph of an equation, when we know only a few points whose coördinates satisfy the equation, is exactly like basing a hypothesis on a few known facts and is essentially non-mathemathical, if mathematics means drawing necessary conclusions, but it may tend to prepare the way for mathematics.

If the graph of an equation is defined as the locus of all the real points whose coördinates satisfy the equation and no others we meet continually with the fundamental difficulty that we cannot construct geometric points or lines but merely things which represent such figures. It is questionable whether this fact should be emphasized by asking the student to construct what represents a graph instead of asking for a construction of the graph itself. If this is not done it should be explicitly stated that we frequently speak of a crude geometric representation as the thing itself and thus use language vaguely in order to secure brevity. When a graph is to be constructed only from a number of points whose coördinates satisfy the equation it might be well to call it a hypothetical graph to emphasize the wide gap between such constructions and the science of drawing necessary conclusions.

In constructing graphs in Cartesian coördinate systems there is a (1, 1) correspondence between the points and their coördinates but in the polar coördinate system there is no uniformity

of procedure as regards this point. In the encyclopedia of elementary mathematics mentioned above, volume 2, page 442, such a (1, 1) correspondence is established by assuming ρ always positive and by limiting θ to an interval of 2π, such as from 0 to 2π. If this is done it is impossible to construct a locus of such curves as $\rho = -\cos^2\theta$ and spirals are generally limited to one spire. On the other hand if we allow ρ to be both positive and negative, and do not limit θ we frequently meet with the condition that some coördinates of a given point satisfy the equation while other coördinates of the same point do not have this property. For instance, the given equation $\rho = -\cos^2\theta$ is not satisfied by any set of coördinates in which ρ is positive but it is clearly satisfied by some coördinates of an infinite number of points if ρ may be negative.

In conclusion we would emphasize the fact that the definitions of elementary and of higher mathematics should be made uniform whenever this is possible without vagueness. Such a term as the angle between two straight lines in the plane, for instance, may be defined as the amount of rotation which one line may undergo around any one of its points and become parallel to the other line. If such a definition leads the student to consider angles whose magnitudes exceed 2π it will add another element of interest and prepare his way for trigonometry. Broad views are more fascinating than the narrow ones and should be encouraged whenever they are sufficiently elementary to be understood by the student. On the other hand, there are many terms whose definitions must grow with the student's knowledge. Even in some of these cases it is possible to give definitions such that only the meaning of the definition broadens as the student advances, but in other cases it seems necessary to make essential changes in the wording of the definition as the student advances in his mathematical development.

EXPERIMENTAL GEOMETRY.

By H. J. Chase,

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In the April issue of School Science and Mathematics the writer condemned the deductive method of learning geometry, taking the ground that beginners can make much more rapid and satisfactory progress by following the inductive or experimental method. The present article is intended to give some practical suggestions as to the employment of the experimental method.

Do not require the pupils to learn a series of definitions at the start; assume that they know a circle when they see one, although not one of them may be able to give the exact meaning of the word. Put compasses into their hands and let them practice describing circles. As soon as the pupils have gained sufficient proficiency require them to describe a circle in the middle of a sheet of unruled paper, and to pass a fine line from left to right exactly through the center and extending on each side some distance beyond the circumference. Let them designate by letters. or numbers, the center and the points where the line crosses the curve. Then give them the proper directions for constructing a second line across the center which shall be perpendicular to the first.

Repeat this exercise as many times as may be necessary, that is, until the pupils can perform it with reasonable facility. They are now ready for questions like the following:

How many corners, or angles, do the lines (that is, the straight lines) make with each other? Into how many parts, or arcs, do they divide the boundary or circumference of the circle? How do these arcs compare with each other in length? Require them to test with their compasses, and, finally, to cut out the circle, divide it along the lines and lay one part upon the other. Lay the parts side by side, as they were before cutting; or, better still, repeat the exercise. Then put questions as follows:

If the circumference of the circle were divided into 360 parts, or degrees, how many of these degrees would lie between the sides of the angle ACD (or whatever its designation may be)? Then, if necessary, inform the pupils that such an angle is a right angle. Also call their attention to the radii, diameters, adjacent and opposite angles.

Next, give directions for bisecting one of the quadrants, and inquire the number of degrees in each of the arcs thus formed; also in the different composite arcs. Next require the bisection of one of the 45° arcs. This opens up more questions as to the number of degrees in composite arcs. Then ask the pupils to construct an angle of 11¼°. Most of them will be able to do it without directions. Using the same center, but a longer radius, require the pupils to describe a circle and extend all the lines in the figure until they intersect its circumference. Question them as to the number of degrees in each of the outside arcs. Using the same center but a shorter radius, require the pupils to describe an inner circle, and question them about the inner arcs. By this time they will have discovered that the size of an angle does not depend upon the length of its sides. By cutting out the circles, beginning with the outer one, and folding along one of the diameters, they will prove that the diameter divides the circle and its circumference into two equal parts. It is assumed that attention has been called to the distinction between circle and circumference. The pupils are now ready for the intelligent investigation of such questions as the following:

What is the sum of any two adjacent angles? Of all the angles about a point and on one side of a line passing through the point? Of all the angles about a point? How do opposite angles compare with each other? If a straight line meets two others at a common point, and the adjacent angles thus formed aggregate 180°, what then? The pupils can find out by *actually doing* the things that the deductive method *supposes* to be done.

To discover the value of the three angles of any triangle, take the vertex of each angle as a center, and with the same radius describe an arc between the sides. With the same radius describe a circle, and from any point on its circumference lay off in succession the three arcs of the triangle. In all cases they will be found to extend half way round the circle. By the same method the aggregate value of the interior angles of quadrilaterals, pentagons, hexagons, and so on, may be found, and a rule evolved that will apply to any polygon. In the course of this investigation the pupils can be taught how to construct the different kinds of triangles and quadrilaterals, how to construct various regular polygons and so on. In all cases of superposition let the pupil construct the figures according to the conditions and

cut one of them out and lay it upon the other. In fact, to *do*, instead of *supposing to be done*, is the keynote of this method. The properties and relations of all the ordinary plane figures can be investigated in this way.

The pupils can construct without serious difficulty, using pasteboard or cardboard, all the regular solids except the sphere. Any tinsmith can make in a few minutes a hemisphere, from which, by comparison with a cone of proper dimensions, the rule for finding the surface of a sphere can be evolved. It should be mentioned that, as soon as the occasion arises, pupils can be taught in a short time the mere process of extracting the square root; although it is not absolutely necessary that they should know the process. Though they can learn most of the facts that constitute elementary geometry without knowing how to extract the square root, why not teach it, leaving the whys and wherefores for some other time?

The writer at first employed the foregoing method, using an ordinary text-book. Any teacher can do the same, simply requiring the pupils to construct figures according to the conditions. In short, this method is, in reality, testing with a pair of compasses the truth of the propositions of Euclid. It would be far better, however, if the formal statements of the propositions could be kept out of the pupil's hands. If rightly directed, he can make his own discoveries, and usually he is able to find some way of expressing what he discovers.

A few words in conclusion. Do not teach a problem of construction until the occasion arises for its employment; that is, until a proposition is reached the conditions of which involve the construction. In constructing prisms, pyramids, etc., require them to be of certain dimensions; leave the bases or one side open, so that the capacities of, for example, a cylinder and a cone equal in base and altitude can be compared by pouring sand, sawdust, or grain from one into the other. Many equivalent plane figures can be made to coincide by superimposing and cutting off the projecting part of one and applying it to the projecting part of the other. The possibilities of this method are but faintly indicated by the foregoing outline. Not infrequently it suggests deductions, and the pupils, if rightly directed, will make the deductions. The writer feels confident that teachers who will accord this method a fair trial will be satisfied with the results.

A METHOD OF FINGER MULTIPLICATION.

By E. J. Rendtorff,

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I wish to present a method of finger multiplication that is interesting and unique, though perhaps of no great practical value, except in special cases, such as determining the square of any number. The method is applicable to the products of any numbers, when these, less one, on being divided by 5 give the same whole number as quotient.

Two cases arise: (1) where the unit digits of the multiplier and multiplicand are from 1 to 5; and (2) where they are from 6 to 0. In the first case the unit digit of the numbers assigned to the thumb is always 1, and in the second case always 6.

Let us attempt to multiply 34 by 33. This would come under the first case. Label the fingers 31 to 35, beginning with the thumb, as shown in the diagram. Hold the fingers labeled 34 and 33 in contact, with the thumbs above and the palms facing the calculator.

Let C and C' be the number of fingers in and above contact, on the two hands; B and B' those below contact; T_t the tens' (hundreds,' etc.) digits of the thumb number; and T_e the tens' (hundreds,' etc.) digits of the little finger number.

Then, in case I:

The units' digit of the product $= C \times C'$

The tens' digit of the product $= (C+C')T_e$

The hundreds' (thousands,' etc.) digit of the prod. $= T_t \times T_e$

In case II:

The units' digit of the product $= B \times B'$

The tens' digit of the product $= (C+C')T_e$

The hundreds' (thousands', etc.) digit of the prod. $= T_t \times T_e$

Reverting to our product of 34×33, we have

$C \times C'$	$=4 \times 3$	$= 12$
$(C+C')T_e$	$=7 \times 3$	$= 21$
$T_t \times T_e$	$=3 \times 3$	$= 9$
	34×33	$= 1122$

Let us now multiply 39 by 38. This would come under case II, where the thumb number is 36 and the little finger number is 40. On holding the fingers labeled 39 and 38 in contact it will be seen that

$B \times B'$	$=1 \times 2$	$= 2$
$(C+C')T_e$	$=7 \times 4$	$= 28$
$T_t \times T_e$	$=3 \times 4$	$= 12$
	39×38	$= 1482$

To show that this method is applicable to the products of numbers of any magnitude, let us determine the square of any number chosen at random, say 9754.

At first, case I applies, and

	$C \times C'$	$=4 \times 4$	$= 16$
	$(C+C')T_e$	$=8 \times 975$	$= 7800$
$T_t \times T_e$, or 975×975	$C \times C'$	$=5 \times 5$	$= 25$
	$(C+C')T_e$	$=10 \times 97$	$= 970$
$T_t \times T_e$, or 97×97	$B \times B'$	$=3 \times 3$	$= 9$
	$(C+C')T_e$	$=4 \times 10$	$= 40$
	$T_t \times T_e$	$=9 \times 10$	$= 90$
		$(9754)^2$	$= 95,140,516$

With this method, after a little practice, the square of any number, or the product of any numbers that can be multiplied, as previously explained, up to 100, can be read off from the fingers much more rapidly than determined by actual multiplication.

THE EXPERIMENTAL VIEWPOINT IN CHEMISTRY.*

By Alexander Smith,

Professor of Chemistry, University of Chicago.

As we look at modern Elementary Chemistry and compare it with the Elementary Chemistry of fifteen, or of fifty years ago, we are able without difficulty to observe many changes and much improvement. I am not now referring to the mere increase in knowledge of the facts of Chemistry, but to a change in the method of presentation, a change which has affected Elementary Chemistry even more than it has the Science as a whole. I think there are two directions which this change has taken that are especially worthy of discussion amongst teachers. One of these is, that *thought* in regard to chemical facts seems to be more straightforward; the other, that the *speech* of Chemistry has become more literal. Both of these effects are the result of speaking and thinking closely in terms of *experimental facts.*

That the language of Elementary Chemistry has not always been as literal as it is now, is evident from an examination of the older books. The figurative language in which Elementary Chemistry used almost exclusively to be expressed was *sui generis,* and contrasted very strikingly with the much more literal language of Elementary Physics. I suppose there has never been a time when specific heat was defined otherwise than as the number of calories required to raise one gram of a substance one degree, or in some such terms as these. How admirable has always been the simplicity of the definition of the boiling point of a liquid, as conceived by the physicist. Imagine a text-book on Physics written by an old-time chemist and conceive, if you can, how he would define the boiling point of water. If he was of the "unreconstructed" type he would perhaps say: "The boiling point of water is the condition at which the kinetic energy of its molecules has been so far increased, and the distances between the molecules have become so great, that the number of them in a given volume is the same as the number of molecules of oxygen in the same volume at 100° and 760 mm.," or words to that effect. Palpably absurd as an atrocity of this description would appear in a work on Physics, we have suffered in Chemistry in the past from too much of this kind of thing. Imagine the pupil taking this definition with him into the laboratory and attempting by

*Abstract of an address before the Chemistry Section of the Michigan Schoolmasters Club at its meeting in March, 1908. The experiments mentioned were shown.

the aid of it to measure the boiling point of water. A statement which is not in terms of experimental facts can be of little use in teaching an experimental science.

It may be worth while to pick out a few illustrations of the characteristics of modern Elementary Chemistry which have just been mentioned. That *thought in Chemistry is more straightforward and more closely in terms of experimental facts* is easy to show. For example, we used invariably to have bleaching mentioned under chlorine. Of course, even at that time, every chemist knew that chlorine by itself would not bleach a dry fabric. This may be illustrated by filling with chlorine a stoppered bottle, the bottom of which has been covered with concentrated sulphuric acid. When the gas has become dry, a piece of colored calico is pinned to a cork and the cork is stuck in the hollow inside the stopper. Finally the stopper is replaced in the bottle. Under these circumstances the rag will remain for weeks without changing its tint. A rag saturated with water does lose its color when exposed to chlorine, but we know that chlorine interacts with water to give traces of hydrochloric acid and hypochlorous acid, and that the latter when used by itself in aqueous solution is a powerful bleaching agent. Since, therefore, chlorine (when dry) and hydrochloric acid are not bleaching substances, it follows that bleaching should be discussed under hypochlorous acid. It is definitely misleading to discuss it anywhere else. The transposition has been made in consequence of a more careful consideration of the experimental facts.

The chemical change involved in bleaching by hypochlorous acid is simple. The substance loses the unit of oxygen which its molecule contains and hydrochloric acid remains. For example, when indigo is the dye affected, the following equation shows the formation of isatin, a relatively colorless substance, and exhibits the actual chemical transformation:

$$2HClO + C_{16}H_{10}N_2O_2 \rightarrow 2HCl + 2C_8H_5NO_2.$$

The explanation of the fact that hypochlorous acid will oxidize indigo, while free oxygen will not do so, has taken various forms. Is it not sufficient to say that hypochlorous acid is an oxidizing agent? The equation then shows exactly what has occurred. We are familiar with many other oxidizing agents and know that it is characteristic of them to excel free oxygen itself in their

ability to produce oxidation. Ostwald explains the effect further by pointing out that, whereas the action of free oxygen upon indigo, if it could occur in practice, would liberate only 1,800 calories, the oxidation of the same quantity of indigo by hypochlorous acid liberates about 20,000 calories. Thus, in producing similar results, hypochlorous acid brings to the furtherance of oxidations in which it takes part a very much greater amount of available energy than does oxygen. These explanations, connecting the fact in question with other large groups of facts, and keeping experiment clearly in view, are a great improvement over the older and now discredited explanation. This, you will remember, was to the effect that the hypochlorous acid first lost its oxygen, and then this free oxygen performed the oxidation. Thus far the explanation was open to the criticism that free oxygen as a matter of fact did not bleach indigo. Instead, however, of going back to the facts at this point, the contradiction was avoided by the bold assumption that this free oxygen was *not* free oxygen, but a fairy variety of abnormal activity. Just as when we make an incautious statement, we are compelled often to back it up by fresh falsehoods, so to make this explanation sound plausible, it was found necessary to assume still further that this oxygen owed its activity to its *very recent liberation.* And at this juncture the perspiring story teller was suddenly rescued from his labyrinth of "supposes" by the brilliant idea that this oxygen must be atomic, while ordinary oxygen was molecular. Without stopping to consider how grateful he should have been to oxygen for happening to be a diatomic gas, the nascent and atomic states were quickly made synonymous terms and enthroned as realities to be utilized upon all convenient occasions. The only difficulty with this explanation is that it is wholly fictitious and is therefore an anomaly in an experimental science. The survival of the fittest, that is to say, of the ideas most fit to survive in an experimental science, have naturally led us gradually to dispense with fictitious explanations of this description whenever experimental ones are available.

Speaking of nascent oxygen naturally reminds us of nascent hydrogen. An interesting set of experimental facts throws a good deal of light on this subject. If we take a very dilute solution of potassium permanganate, add to it excess of dilute sulphuric acid, and then divide the solution into four parts (one of which is kept for reference), the needlessness of the nascent

theory may quickly be demonstrated. Hydrogen gas is led through one of the solutions and no effect is observed. A little platinum-black* is added to the second and hydrogen led through the mixture as before. In this case the reducing activity of the hydrogen is greater and the solution is quickly decolorized. To the third tube zinc dust is added and here also the color quickly disappears. Why, however, should we say that it is "nascent" or "atomic" hydrogen which has performed the reduction in the last case, when we perceive that ordinary hydrogen in contact with platinum is just as active in producing the same effect? Clearly, it is simpler to classify this influence of the platinum and of the zinc upon the hydrogen along with the numberless contact actions with which we are so familiar. If confirmation is needed of this view we have only to consider some additional facts. For example, if reductions by hydrogen are due to the presence of atomic hydrogen, all sources of free hydrogen should be equally active, whereas, if the effect is due to contact action, then the apparent activity of the hydrogen will vary according to the nature of the substances acting as contact agents. Now in point of fact the latter is the true state of affairs. Nascent hydrogen from different sources is notoriously different in activity. To cite only one example, when we electrolize dilute sulphuric acid with electrodes made of platinum, and cause oxygen gas to bubble through the liquid near to the negative pole, we find that the hydrogen reduces a part of the dissolved oxygen so that hydrogen peroxide is found in the liquid. When, however, a carbon pole is substituted, the hydrogen, although it is liberated with equal facility by the action of the current, and is presumably neither more nor less "'atomic" than before, and is certainly equally "nascent,"—*this hydrogen* has no effect upon dissolved oxygen, and no hydrogen peroxide is produced. The nascent idea is not only purely fictitious, but fails when all the facts are considered. The contact theory involves only facts. It classifies the phenomena of nascent action along with a large number of other facts described as contact actions, and so unifies our ideas.

To avoid misunderstanding, it must be stated explicitly that modern views do not require us to give up the molecular and

*This can be made in a few minutes by placing granulated zinc in a solution of chloroplatinic acid ("platinum tetrachloride"). After the liquid has lost its color, the zinc is removed and the black precipitate, consisting of metallic platinum, is washed upon a filter. The same sample can be used over and over again for the above experiment.

atomic hypotheses. Far from giving them up, we find them most useful in the explanation of many facts. For example, the molecular hypothesis throws much light upon the facts which we observe when ammonium chloride is heated in a horizontal tube. Why does the ammonia reach both ends sooner than does the hydrogen chloride? Because its molecules, once they have been liberated, are independent of those of the hydrogen chloride and move faster in every direction than do the latter. Which, of the two gases, is first liberated in this action? Evidently, when a molecule of ammonium chloride decomposes, the molecules of ammonia and hydrogen chloride must be formed *simultaneously*. The molecular theory is indispensable for the explanation of many things. Our contention is, simply, that hypotheses should be used only when required. We believe that direct correlation with *other facts* constitutes a more scientific explanation than does an indirect correlation by the help of an hypothesis, and that therefore the former process should receive the preference.

That our *speech in Chemistry is in closer harmony with the facts* than it used to be, is also easily demonstrated. We used to talk about "testing for sulphuric acid," whereas now we express our meaning better by saying that we test for the sulphate radical, or, if we are very much up to date, for the sulphate ion. (For beginners I think that the former term is preferable to the latter.) We used to say that the yellow color of muriatic acid was due to the presence of "iron," and were disturbed to find that beginners took the statement literally and expected to see the metal (iron) in the liquid. This form of statement was necessarily confusing. Gradually we are learning that beginners, like children, are apt to take conventional phrases literally, and that for lucid explanation to beginners it is better to use exact language than to employ laboratory slang. We speak conventionally of a test for "chlorine," and only a chemist can tell whether we refer to the use of potassium iodide and starch as a test for free chlorine, or to the use of silver nitrate as a test for the chloride radical. Then, a few minutes later, we speak of bleaching by chlorine, when the substance to which we really refer is hypochlorous acid. Naturally nothing but confusion could arise from loose forms of expression such as these. In this connection I should like to call your attention to the electromotive series of the metals, which is one of the most useful and literal devices we have for explaining a large number of chemical facts. The series runs as follows:

Potassium	**Cadmium**	**Arsenic**
Sodium	**Iron**	**Bismuth**
Barium	**Thallium**	**Antimony**
Strontium	**Cobalt**	**Mercury**
Calcium	**Nickel**	**Silver**
Magnesium	**Tin**	**Palladium**
Aluminium	**Lead**	**Platinum**
Manganese	**Hydrogen**	**Gold**
Zinc	**Copper**	

Each of these elements when in the free condition will displace any of the following elements from combination, when the latter element constitutes one of the radicals of a dissolved compound. The first use of the table (which may be hung in the class room as a chart) occurs when hydrogen is being discussed. The metals preceding hydrogen all displace this element from dilute acids. Those following do not. When we come to speak of the action of hydrogen upon oxides we note the fact that the oxides, beginning with that of zinc, are all reduced to the metallic state, while those preceding zinc are not so reduced. The oxides of mercury and the metals following it can be reduced by heating alone. When we speak of the occurrence of metals in nature, we note the fact that only those metals occur in the native condition which follow hydrogen in the list, and are therefore unable to displace hydrogen from the dilute acids (chiefly carbonic acid) contained in natural waters. Again, colloidal solutions of the metals towards the end of the list can be prepared, because these metals do not interact with water to displace hydrogen, while the preparation of such solutions with the other metals is naturally impossible. The stability of all the compounds of each metal is shown roughly by the position of the metal in the list. Thus the chlorides of the metals from silver onward are decomposed by simple heating, while the chlorides of those above silver are more and more stable. To avoid misunderstanding it should be noted, however, that this table explains only the displacement of a *free element* by means of *another free element,* and has nothing to do with changes which occur in double decomposition. In actions of the latter description it is the insolubility or volability of the product which determines the action, and never the activity which the element would have if it were present in the free condition. Thus, when cupric sulphate is added to lead nitrate solution, the "copper" displaces the "lead" because lead sulphate is insoluble. *Free copper,* however, never displaces lead in the metallic condition from any simple compound.

It is easy to multiply examples of the improvement which has taken place in the language used in Elementary Chemistry. Thus, instead of defining an atomic weight as "the weight of an atom," or even as "the relative weight of an atom" of the element, which, though strictly correct, is a purely theoretical definition, we now prefer to say that the atomic weight of an element is the unit quantity of that element by means of which the proportions of the element in all its combinations is expressed. (Of course a statement as to the method used in choosing the unit quantity is required for a complete definition.)

The test of the value of a definition comes when we ask whether the pupil could conceivably verify the definition in the laboratory. We could imagine his verifying the modern definition of an atomic weight, but the verification of the hypothetical definition, as it stands, is necessarily impossible. So again a formula may be said to represent the kinds and numbers of atoms in a molecule of a particular compound. If, however, we recall the necessity for connecting the theoretical with the experimental work we prefer rather to say that the formula is an expression representing the elements present in a compound, and the proportions by weight in which they are present. There is a difference of opinion amongst teachers of Elementary Chemistry as to whether definitions should be given at all. This question we are not, for the moment, discussing. If, however, we decide that definitions should be given, it is perfectly clear that they should be stated in experimental terms. The order of presentation involves three stages; first the clear statement of the facts; second, if necessary, the study of the relations between these facts by the help of an hypothesis; third, the statement in terms of experimental facts of the relations thus discovered, with careful exclusion of everything of a hypothetical nature. Molecules, atoms, and ions are conceptions which help us greatly in explaining facts, but after the relations between the facts have thus been made clear, our final idea should as far as possible be stated in terms of facts only.

In this connection, let me suggest that a wonderful clarification of one's own ideas about many things can be brought about by the following exercise: Take the terms commonly used in Chemistry and prepare two definitions of each, one a theoretical definition, the other an experimental definition from which every-

thing hypothetical is carefully eliminated. It will then be evident how far, in our own minds, we have been confusing fact with theory. What, for example, is a graphic formula? Is it a mode of representing valence? Or shall we say that it is a mode of representing the arrangement of the atoms in a molecule? These are theoretical definitions. Or shall we say that it is a mode of representing the chemical behavior of a substance? This is the experimental definition. If we apply this process to such terms as: element, compound, law of definite proportions, law of multiple proportions, symbol, formula, valence, molecular weight, molecule, physical property, chemical property, physical change, chemical change, etc., we shall discover that even our own views have not always been as clear as we thought they were. To prepare satisfactory definitions, of both kinds, for the last four conceptions, for example, is not an easy matter, and a good deal of useful mental exercise can be secured by making the attempt. I do not wish to be understood to mean that this process is to be discussed with the pupil. It may even be better to avoid abstract statements of all descriptions with young pupils. It is clear, however, that if any sharply formulated generalizations are to be given at all, then the ones in which experimental terms are used exclusively are the only ones which will be of permanent service to the pupil.

In the foregoing I have attempted, by means of illustrations, to show what appear to me to be some of the characteristics of modern elementary Chemistry. I have tried to show that our thought, for example, about bleaching by hypochlorous acid, or reducing by nascent hydrogen, is now in closer touch with experimental facts. I have tried to show that our language is in many ways more literal and less impregnated with hypothetical ideas than it used to be. That these changes have been of great value in the teaching of the science cannot be questioned. Amongst the benefits which may be noted are the following: In the first place, there is the greater certainty that our statements will be understood by our pupils. In the second place, these improvements necessarily have brought about a closer relation between the instruction in the class room and the work in the laboratory. The commonest complaint of our pupils used to be that there seemed to be too little connection between the practical work and the class room work. I am convinced that most

of this difficulty was attributable to the fact that in the class room our language was wholly figurative, while in the laboratory, in direct contact with the substances and their behavior, the figurative vocabulary and the battery of figurative conceptions necessarily seemed out of place and was discarded. When we consider the use to which our pupils will afterward put the training in Chemistry which we have given them in a secondary school, we perceive two additional advantages of the experimental method of expression. The pupils who later continue the study of the science under another instructor will have no difficulty in utilizing any facts which they may have acquired. The experimental method of teaching cannot help but fit on to later instruction of any description. A theoretical variety of instruction is almost certain to be more difficult of adjustment. Again, many of our pupils, in most cases the great majority, do not continue the study of the science. It is evident, however, that when these go into business, an ability to talk in terms of hypothetical conceptions in Chemistry can be of but a little use to them. In business the things which count are, the ability to ascertain facts, to handle facts, and to relate them to one another, and the power to draw from the facts concrete conclusions which are suited to form a basis for action. The experimental viewpoint will make the study of Chemistry in a secondary school a valuable instrument for sound mental training. Whether, therefore, we consider our duty to the science which we have the privilege of teaching, or to the pupils, a part of whose mental discipline has been placed in our charge, there can be no question that a training which emphasizes the importance of facts, and trains in thought in terms of fact, will be, in the long run, by far the most valuable.

SCIENCE TEACHING IN SCHOOLS.

By Arthur S. Dewing,

Harvard University.

A study in the relation of science teaching to the general problems of education.

I. The Educational Idea in Science Teaching.

The problem of science teaching in our schools is closely allied to other tendencies. First among these is the paramount interest of Americans in things practical. We have come to gauge the value of human effort in terms of the immediate practical results that are likely to accrue from it. At the last analysis we do not know exactly what we mean by the value involved, but we have an indistinct realization that nothing is of real worth unless it can be directly connected with some result of conspicuous benefit to mankind, individually or collectively, economically or socially. This general attitude of mind can not but affect all with which it comes in contact and it has profoundly influenced educational theory. We have discarded as much as possible those subjects of study the benefits of which are only indirect, and in their place we have put those things which are of immediate and obvious advantage. Greek and Latin are replaced by mathematics and the sciences. The change has been brought about simply by the change of attitude of the world at large, a change which is coincident with an altered point of view. The world of today is not interested in the issue between Augustine and Pelagious, nor even in that between Agassiz and Darwin; much more is it interested in whether powers of the monopolies should be predetermined, or whether it is possible to breed seedless oranges and thornless roses. Education must look at this matter squarely from the front. It is futile to discuss whether the widespread substitution of the sciences for the classics is theoretically sound—for in the end that depends on what theory of education one adopts—much better is it to outline the best way of teaching the sciences and vindicate the high mission of education by proving its power in any field. Society wants the things of practical moment taught and it is the task of education to do it and to do it well.

The advantages which science teaching possesses are very distinct. Above all it has the confidence of the people before whose

court of public opinion it must justify the results of its endeavor. In point of its subject-matter it has the very great advantage of teaching something from first-hand acquaintance; it need not resort to artificial means for making its facts real and vital. Again it deals with subjects which may be correlated with general laws and principles, making it unnecessary for the teacher to invent and infuse with some kind of reality an artificial scheme of staging and presentation. Science teaching has every natural advantage in its favor, the keen interest of the average pupil not excepted, and it is science teaching itself that must prove its own success in meeting the demands of education —and no ordinary excuse can be offered for its failure.

There are two fundamental problems which those interested in the teaching of science must face. One of these is concerned with the ideal which science teaching shall follow and the other with the manner with which it pursues its ideal. In regard to the first problem it must be remembered that no part of our educational system can long withstand the demand of the modern educational critics to justify itself in the light of a broad understanding of educational principles. However much the scientists may scoff at the controversies of the educational theorists it is nevertheless true that the teaching of science as a part of the school program must meet the issues of those very problems which educational theory has been struggling with for many years.

Education is a broad term. It has, however, a specific meaning. Not all the exercises of the memory, not all the training of hands to do intricate tasks, not all that is taught in our schools can be said to educate. Education is distinct from learning, distinct even from knowledge; it is more subtle, more latent and more unconscious than fact-knowledge. Education represents mental power.

The teaching of science, if it is to contribute towards education and not pedantry, must meet the requirements of the former by showing how and in what manner and to what degree the mind is to be cultivated through its agency. This demands a thorough understanding of just the task that education proffers to the teachers of science in our schools. If we are to look upon education as essentially a process of mental development it is necessary to consider the character of the process. Expressions such as mental development have a broad and usually inexact

significance. Education is too prone to refer to any process wherein the mind is employed as a process of education. There is, however, a very considerable difference in point of value in the different ways in which the mind can be employed. Difference in function brings about difference in result. If the emphasis is laid upon the training of the memory the final result will be the development of the capacity of the memory at the expense of the acuteness of the observation, the penetration of the reason and the scope of the imagination. Education in its truest sense is not narrow. It must pay its due regard to every valuable mental function. In this effort the reason, the perception and the imagination must be considered.

The training of the powers of observation must of necessity lie at the basis of any science teaching. Science has never deviated from the belief that knowledge has its foundation at least in the facts of experience, as one of its masters said, "Without doubt all our human knowledge has its origin in experience." The training of the observational powers consists, however, in a good deal more than simply the taking in of heterogeneous experiences as they flow along the stream of consciousness. Each separate and isolated content of experience has its own particular value, its significance to the whole, be that whole the conception of mass action or biological inheritance.

Acuteness of observation is necessarily the beginning of scientific training but it is not the end. Knowledge has its beginning in experience but experience is not knowledge. Science is, however, particularly well fitted to afford mental training, but it must be remembered that this training is a slow process in which the student learns to think by thinking. Text-books and even laboratory methods, in which the students merely go through the activity of performing an experiment, in short "the verification method" does not train to think because it lacks just that element of spontaneous activity which lies at the basis of the reasoning process.

Although it may be true that scientific imagination is one of the most difficult phases of our mental life to cultivate, it need not therefore be neglected. No science is the dull routine of facts that some teachers make it. It has life, vigor and imaginative color.

If the similarity between these various processes of mental life is as deep as it thus appears the bearing on education is

apparent. Science teaching, if it is to achieve its best results must consider carefully its relation to the various mental processes which education in general is required to consider. Science teaching is in a preëminent position to accomplish something thoroughly worth while in education, provided it retains a broad appreciation of what is required in education and does not seek to make the raw materials of science, the dry dust of fact, superior to the living, vital force of the mind. Science, like Greek or Latin, can teach the roots for the roots' sake, or it can teach the spirit of its subject, for the sake of the human being that is learning. Science, like anything else that men may teach and boys may learn, can be made to widen the intellectual grasp of the student, or it may merely add facts to the memory stock of the pedant. Which of these ends science teaching accomplishes depends on the point of view of the teacher. Education rightly requires that the perception, the reason and the imagination shall all be cultivated as fully as possible by any system of teaching that pretends to educate. These considerations have a very practical bearing on the methods of teaching. The excellency of a method is to be judged by the success with which it meets these ideal requirements of educational value, the defect of a practical method of teaching is to be judged by the deficiency of result in meeting the ideal standards.

(*To be continued.*)

THE ELECTROLYTIC RECTIFIER.

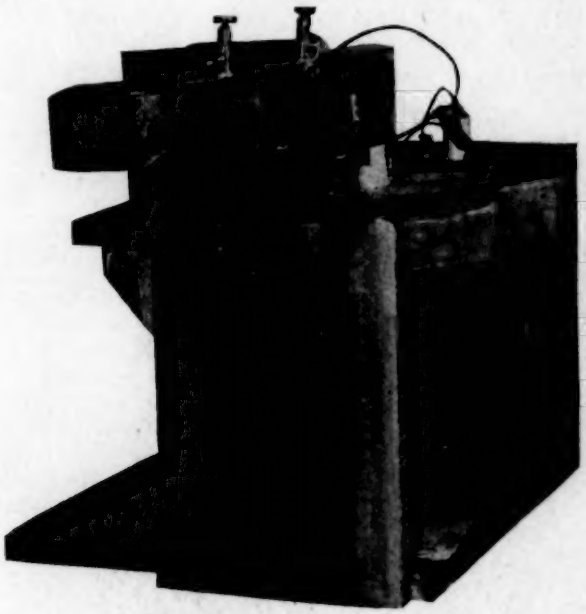
By H. C. Shurlock,

Howard University, Washington, D. C.

The production of a unidirectional current from the alternating lighting circuit for such work in the laboratory as can be done only with the direct current may be accomplished in several ways: (1) a direct current generator driven by an alternating current motor; (2) a rotary converter; (3) a mechanical rectifier; (4) the mercury arc rectifier; (5) the electrolytic rectifier. Among these the electrolytic rectifier finds a large place, being cheap and at the same time convenient and of a high per cent. of efficiency. All such rectifiers as now made consist of an iron or lead plate in combination with an aluminum plate immersed in a suitable electrolyte, usually a solution of a phosphate. All have the aluminum plate for the action depends upon the peculiar property of alum-

inum by which it offers a high resistance as the anode (by formation of oxide) and a very low resistance as the cathode of an electrolytic cell.

For ordinary laboratory purposes there must be means for controlling the voltage of the alternating current delivered to the apparatus. Lamp rheostats are in common use to this end, but the auto-transformer has certain advantages, though by far the greater portion of the labor in making the rectifier lies in its construction. By inserting into the direct current circuit a suitable adjustable resistance both its voltage and amperage can be nicely controlled to suit most of the work which the experimenter may desire.



The rectifier figured is one which I have constructed according to specifications given by Mr. Frederick Ward in the Scientific American Supplement of July 6, 1907. The apparatus was hurriedly made and is not presented with particular reference to excellence of finish or mounting. It will be seen from the cut that the auto-transformer is supported on a shelf at the rear. The end loops of the various layers of the coil are led to the front through holes drilled in the board and are secured in one opening of double connectors; the binding posts at the top receive the coil terminals. Screws are driven through the board into the heads of the coil spool to give greater security.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

103. *Proposed by J. J. Browne, Golden, Colo.*

Factor $(la' + l'a)^3\ (bc' - b'c)^3 + (lb' + l'b)^3\ (ca' - c'a)^3 + (lc' + l'c)^3\ (ab' - a'b)^3$.

Solution by A. W. Rich, Worcester, Mass.

Remove parentheses and simplify:

$$\underset{1}{3aa'^2b^3c'^3l'^2l'} + \underset{2}{3a^2a'b^3c'^3ll'^2} - \underset{3}{3a'^3b^2b'cc'^2l'^3} - \underset{4}{3a^3b^2b'cc'^2l'^3} + \underset{5}{3a'^3bb'^3c^2c'l'^3}$$

$$+ \underset{6}{3a^3bb'^2c^2c'l'^3} - \underset{7}{3aa'^2b'^2c^3l'^2l'} - \underset{8}{3a^2a'b'^2c^3ll'^2} + \underset{9}{3a'^3bb'^2c^3l'^2l'} + \underset{10}{3a'^3b^2b'c^3ll'^2}$$

$$- \underset{11}{3aa'^2b'^3c^3c'l'^3} - \underset{12}{3aa'^2b^3c^2c'l'^3} + \underset{13}{3a^2a'b'^3cc'^2l'^3} + \underset{14}{3a^2a'b^3cc'^2l'^3} - \underset{15}{3a'^3bb'^2c'^3l'^2l'}$$

$$- \underset{16}{3a^3b^2b'c'^3ll'^2} + \underset{17}{3a^3b'^3cc'^2l'^2l'} + \underset{18}{3a^3b'^3c^2c'll'^2} - \underset{19}{3a^2a'bb'^2c'^3l'^3} - \underset{20}{3a^2a'bb'^3c^2l'^3}$$

$$+ \underset{21}{3aa'^2b^3b'c'^3l'^2} + \underset{22}{3aa'^2b^2b'c^3l'^2} - \underset{23}{3a'^3b^3cc'^2l'^2l'} - \underset{24}{3a'^3b^3c^2c'll'^2}.$$

Take out the common factor 3, rearrange, group and factor the parentheses:

$$\underset{3\ 6}{a^2b^2c'^3ll'^2}(a'b - ab') + \underset{5\ 11}{a'^2b'^2c^2c'l'^2}(a'b - ab') + \underset{9\ 7}{a'^2b'^2c^3l'^2l'}(a'b - ab')$$

$$+ \underset{24\ 4}{a^2b^2cc'^2l'^3}(a'b - ab') + \underset{21\ 19}{aa'bb'c'^3l'^2}(a'b - ab') + \underset{22\ 20}{aa'bb'c^3l'^3}(a'b - ab')$$

$$+ \underset{1\ 5}{abc'^3l'^2l'}(a'^2b^2 - a^2b'^2) - \underset{3\ 12}{a'b'cc'^2l'^2}(a'^2b^2 - a^2b'^2)$$

$$- \underset{12\ 6}{abc^2c'l'^3}(a'^2b^2 - a^2b'^2) + \underset{10\ 8}{a'b'c^2ll'^2}(a'b^2 - a^2b'^2)$$

$$- \underset{23\ 17}{cc'^2l'^2l'}(a'^2b^3 - a^3b'^2) - \underset{24\ 18}{c^2c'll'^2}(a'^2b^3 - a^3b'^2).$$

Take out the common factor $(a'b - ab')$:

$$\underset{1}{a^2b^2c'^3ll'^2} + \underset{2}{a'^2b'^2c'l'^3} + \underset{3}{a'^2b'^2c^2l'^2l'} + \underset{4}{a^2b^2cc'^2l'^3}$$

$$+ \underset{5}{aa'bb'c'^3l'^2} + \underset{6}{aa'bb'c^2l'^3}$$

$$+ (abc'^3l'^2l' - a'b'cc'^2l'^3 - abc^2c'l'^3 + a'b'c^2ll'^2)\ (a'b + ab')$$
$$- (cc'^2l'^2l' + c^2c'll'^2)\ (a'^2b^2 + a'bab' + a^2b'^2).$$

Rearrange the first six terms in the order 1, 4, 2, 3, 5, 6 and factor them, and also the first parenthesis:

$$(c'l + cl')\ [a^2b^2c'^2l'^2 + a'^2b'^2c^2l'^2 + aa'bb'(c'^2l'^2 - c'lcl' + c^2l'^2)] + (c'^2l'^2 - c^2l'^2)\ (abc'l' - a'b'cl)\ (a'b + ab')$$
$$- cc'll'\ (c'l + cl')\ (a'^2b^2 + a'bab' + a^2b'^2).$$

Take out the common factor $(c'l + cl')$ and rearrange:

$a^2b^2c'^2l'^2 + a'^2b'^2c^2l^2 - 2aa'bb'c'lcl' + aa'bb'(c'^2l^2 + c^2l'^2) + (c'l - cl')(abc'l' - a'b'cl)(a'b + ab') - cc'll'(a'^2b^2 + a^2b'^2)$.

Remove parentheses, rearrange and factor:

$(abc'l' - a'b'cl)^2 + (abc'l' - a'b'cl)(ab'c'l - a'bcl') + (abc'l' - a'b'cl)(a'bc'l - ab'cl') + (a'bc'l - ab'cl')(ab'c'l - a'bcl')$.

Group and factor:

$(abc'l' - a'b'cl)(abc'l' - a'b'cl + ab'cl' - a'bcl') + (a'bc'l - ab'cl')(abc'l' - a'b'cl + ab'c'l - a'bcl')$.

Factor:

$(abc'l' - a'b'cl + ab'c'l - a'bcl')(abc'l' - a'b'cl + a'bc'l - ab'cl')$.

Factor:

$(ac' - a'c)(bl' + b'l)(bc' - b'c)(al' + a'l)$.

The required factors are:

$3(a'b - ab')(c'l + cl')(ac' - a'c)(bl' + b'l)(bc' - b'c)(al' + a'l)$.

108. *Proposed by Lloyd Holsinger, Peoria, Ill.*

If $ax + by + cz = 0$ and $\frac{a}{x} + \frac{b}{y} + \frac{c}{z} = 0$, prove that $ax^3 + by^3 + cz^3 = -(a + b + c)(y + z)(z + x)(x + y)$.

I. Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

Expanding and collecting terms on the right hand side we obtain: $-(ayz + bxz + cyx)(x + y + z) - (ax + by + cz)(xy + xz + yz) - (ax + by)z^2 - (ax + cz)y^2 - (by + cz)x^2$. But $\frac{a}{x} + \frac{b}{y} + \frac{c}{z} = 0$ gives $ayz + bxz + cyz = 0$; and from $ax + by + cz = 0$ we have $ax + by = -cz$, $ax + cz = -by$, $by + cz = -ax$. Substituting these values in the above, we obtain: $ax^3 + by^3 + cz^3$.

II. Solution by I. L. Winckler, Cleveland, Ohio.

Multiply the given equations by $x^2 + y^2 + z^2 + yz + zx + xy$ and $x + y + z$ respectively, after clearing the second of fractions, and add the resulting equations. We have $ax^3 + by^3 + cz^3 + (a + b + c)(x^2y + x^2z + xy^2 + y^2z + xz^2 + yz^2 + 2xyz) = 0$. Hence $ax^3 + by^3 + cz^3 = -(a + b + c)(y + z)(z + x)(x + y)$.

109. *Proposed by J. O. Mahoney, Dallas, Texas.*

How many angles are formed by lines connecting n points in a plane? How many diagonals may be drawn in an ordinary figure of n sides?

Solution by W. L. Malone, Fern Hill, Washington.

The number of lines joining n points, no three being collinear is $n(n - 1)/2$. In general each pair of lines intersect, and the number of pairs of lines is equal to the number of intersections

$$\frac{\frac{n(n-1)}{2}\left[\frac{n(n-1)}{2} - 1\right]}{2} = \frac{(n+1)n(n-1)(n-2)}{8}.$$

At each intersection there are four angles each less than 180°, hence the number of angles required is

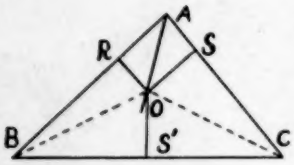
$$\frac{(n+1)n(n-1)(n-2)}{2}.$$

The number of diagonals is equal to the number of lines, minus $n = n(n-1)/2 - n = n(n-3)/2$. [The intersections are not necessarily separate points.]

Geometry.

107. *Proposed by Walter L. Brown, Fancher, N. Y.*

Find the fallacy in the following argument: "All triangles are isosceles."



Proof: Bisect the vertical angle A by the line AO, and let this line meet the perpendicular bisector of BC in O. Draw OS perpendicular to AC and OR perpendicular to AB. Connect OB, OC. Then RO = OS, OB = OC, angle BRO = CSO being right angles, and therefore RB = SC. Likewise AR = AS. By addition it now follows that AB = AC.

I. Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

The bisector of one angle of a triangle and the right bisector of the opposite side never intersect within the triangle. The bisector of the angle divides the opposite side into segments proportional to the sides adjacent to those segments. If the sides are equal, the cutting point is the mid point of the opposite side, if unequal it is nearer the shorter side and the right bisector of the third side cuts the angle bisector without the triangle.

II. Solution by Walter L. Brown, Eugene R. Smith and F. J. Taylor.

Except in the case of an isosceles triangle the point O lies without the triangle and either R or S lies on a side of the triangle produced. The fallacy consists in calling AB the sum of AR and RB, and CA the sum of AS and SC. The longer one will be the sum and the shorter one the difference.

Remark by W. F. White, Ph.D., New Platz, N. Y.

See Ball's Mathematical Recreations, pages 44 and 45.

110. *Proposed by W. L. Malone, Fern Hill, Wash.*

Through two given points draw a circle tangent to a given circle.

Solution by R. C. Shellenbarger, Yankton, S. D., and F. J. Taylor, Merriam Park, Minn.

Through the two given points A and B draw a circle intersecting the given circle in E and F. Let the line EF meet AB in P. From P draw PT and PT' tangent to the given circle. A circle through ABT or ABT' will be the one required since $PF \times PE = PT^2 = PT'^2 = PA \times PB$.

111. *Proposed by R. C. Shellenbarger, Yankton, S. D.*

Find the radius of a circle having given the length and height of an arc in linear units.

Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

Let l be the length and h the height of the arc, in linear units; r the radius of the circle and θ the angle at the center. Then $l = \pi r\theta/180$ or $r\theta = 180l/\pi$. Also $\cos\frac{1}{2}\theta = (r-h)/r$ or $\theta = 2\cos^{-1}(r-h)/r$. We have therefore, for the determination of r, the equation $90l/\pi = r\cos^{-1}(r-h)/r$.

Applied Mathematics.

112. *Proposed by G. B. M. Zerr, Ph.D., Philadelphia, Pa.*

The specific gravity of copper is 8.8, of aluminum 2.5. The price of copper is 16 cents per pound, of aluminum 35 cents per pound. The conductivity of copper to aluminum = 100 : 65. Which is the cheaper for electrical conductors?

Solution by Walter L. Brown, Fancher, N. Y.

The ratio of the costs is:

$$\frac{8.8 \times 16 \times 65}{25 \times 35 \times 100} = \frac{.36608}{.35} = \frac{1.046}{1},$$

and the aluminum is cheaper.

Remark by W. L. Malone.

As a practical problem the result may be misleading. The tenacity is an important property. One company has had to replace its aluminum conductors with copper because aluminum would not stand the stresses and if made large enough to do so, the cost would exceed that of copper. The tenacity of copper to that of aluminum is 2 : 1 and if this be used instead of the ratio of conductivity, we get the cost of copper : cost of aluminum = 1 : 1.243.

Miscellaneous.

(I hereby offer a prize of three dollars for the best solution of the following problem. Address all solutions to Ira M. DeLong, Boulder, Colo.—O. R. SHELDON, Chicago, Ill.)

A magician asked his audience to announce in order the three remainders resulting from the division by 7, 5, and 3 of any integer from 1 to 100. He claimed to be able to tell without a moment's hesitation what integer was used. How could he do this?

The Editor received twenty-eight solutions of Mr. Sheldon's prize problem, some depending upon memory, others upon analysis, and still others upon some union of these two agencies. Most of the solutions are interesting, and some are distinctly meritorious; but it has been no easy task to decide which one definitely excels all others. Understanding that the Problem does not call for the most rigorous or elegant investigation, but rather for the most certain and expeditious way of announcing correct results, the Editor publishes below the three solutions which appeal most strongly to him, and among these three awards the first place to the one by Mr. S. E. Curtiss. Our readers will find an interesting discussion of this problem in Ball's excellent work, Mathematical Problems and Recreations. It remains only to add that the Editor's associate, Dr. S. Epsteen, assisted him in comparing the different solutions, in subjecting the better ones to a careful test by the watch, and in arriving at the final decision.

I. Solution by S. E. Curtiss, 711 Emerson St., Evanston, Ill.

Let the numbers after division by 7, 5, 3 be a, b, c respectively. B is the number between 1 and 5 inclusive which is $a-b$ or $a-b\pm5$, and C is the number between 1 and 3 inclusive which is $a-c$ or $a-c\pm3$. The performer must memorize the following table:

B \ C	1	2	3
1	2	7	12
2	14	4	9
3	11	1	6
4	8	13	3
5	5	10	0

To obtain the required number multiply by 7 the number x which is in the row opposite B and in the column under C, and add a to the result. In fact the table is so formed that $2x$ + B is divisible by 5, and x + C is divisible by 3. Hence there are integers y and z such that $7x + a - b = 5y$, $7x + a - c = 3z$, i. e.,

$$7x + a = 5y + b, \qquad 7x + a = 3z + c.$$

This shows that the remainders resulting from the division of $7x + a$ by 7, 5, 3 are a, b, c.

II. Solution by E. B. Escott, Ann Arbor, Michigan.

Let x = the number, and let a, b, c be the remainders. By the conditions of the problem we have

$$x = 7d + a,\ x = 5e + b, \qquad x = 3f + c,$$

where d, e, f are some integers. Multiply the first equation by 3×5, the second by 7×3, and the third by 7×5 and add. We have

$$41x = 15a + 21b + 70c + \text{multiple of } 105.$$

Solving for x we obtain

$$x = 15a + 21b + 70c + \text{multiple of } 105 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Another form of this result, convenient for computation, is:

$$x = 15a + 7(3b - 5c).$$

III. Solution by Harris F. MacNeish, Chicago, Ill.; and Florence Rothermel, Camden, N. J.

Let x represent the integer used and a_7, a_5, a_3 the announced remainders. Find the number b below 15 which when divided by 5 and 3 has remainders a_5 and a_3. Let b_7 represent the remainder when b is divided by 7. Then

$x = 15(a_7 - b_7) + b$ when $a_7 > b_7$, and

$x = 15(a_7 + 7 - b_7) + b$ when $a_7 < b_7$.

The number b determined above is the least positive integer giving the required remainders a_5, a_3. Any number of the form $15k + b$ will give the same remainders a_5, a_3 when divided by 5 and 3. b gives the b_7 when divided by 7. $15k$ gives the remainder k when divided by 7. Any number $15k + b$ then gives a remainder $k + b_7$ when divided by 7. Therefore $k + b_7 = a_7$ for $b_7 < a_7$ and $k + b_7 = a_7 + 7$ for $b_7 > a_7$. Therefore $x = 15(a_7 - b_7) + b$ or $x = 15(a_7 + 7 - b_7) + b$ according as $a_7 > b_7$ or $a_7 < b_7$.

IV. Remark by I. L. Winckler, Cleveland, Ohio.

See Ball's Mathematical Recreations and Essays, page 5.

Credit for Solutions Received.

Algebra 103. A. W. Rich (1).

Geometry 105. Eugene R. Smith (1).

Geometry 107. T. M. Blakslee, Walter L. Brown, A. M. Harding, Gertrude L. Roper (2 solutions), Eugene R. Smith, F. J. Taylor, W. F. White, I. L. Winckler, G. B. M. Zerr. (10).

Algebra 108. Walter L. Brown, I. S. Van Gilder, A. M. Harding, W. L. Malone, Eugene R. Smith, I. L. Winckler (2 solutions), G. B. M. Zerr. (8).

Algebra 109. Walter L. Brown, J. O. Mahoney, W. L. Malone, C. Smedley, Eugene R. Smith, I. L. Winckler, G. B. M. Zerr. (7).

Geometry 110. Walter L. Brown, C. S. Cory, R. C. Shellenbarger, Eugene R. Smith, F. J. Taylor, I. L. Winckler, G. B. M. Zerr. (7).

Geometry 111. Walter L. Brown, I. L. Winckler, G. B. M. Zerr. (3).

Applied Mathematics 112. Walter L. Brown, W. L. Malone, I. L. Winckler, G. B. M. Zerr. (4).

Prize Problem. T. M. Blakslee (3 solutions), Walter L. Brown, Mary E. Caster, C. S. Cory, J. T. Crawford, S. E. Curtiss, E. B. Escott, Frederick Gamsu, W. H. Hays, Albert E. Hennings, Henry A. Levy, H. F. MacNeish (2 solutions), J. O. Mahoney, W. L. Malone, Edward Morgan, A. W. Rich, William F. Rigge, F. G. Rollins, Florence Rothermel, Eugene R. Smith (3 solutions), Samuel F. Tower, I. L. Winckler, G. B. M. Zerr. (28).

Total number of solutions, 69.

PROBLEMS FOR SOLUTION.

Algebra.

118. Find two simple fractions whose denominators are 9 and 5 and whose sum is $2\frac{22}{45}$.

119. *Proposed by A. J. Lewis, A.B., Denver, Colo.*

A and B start to build a brick chimney in the form of a frustum of a pyramid, the lower and upper bases of which are 10 and 2 ft. respectively, the altitude 50 ft. and the flue 20 inches square throughout. They decide that the amount of work in laying is $\frac{3}{5}$ of the amount of work in carrying. A begins laying and B carries for him. How high must they go before B begins laying and A carrying if they each want to do an equal amount of work?

Geometry.

120. *Proposed by Gertrude L. Roper, Detroit, Michigan.*

A man has a 400 ft. lot facing a north and south street. The north and south lines are 1200 and 1500 ft. respectively. The lot runs to an angling street and measures 500 ft. Where shall he build a fence parallel to the 1200, 1500 sides so that his two sons may share equally in the estate?

121. *Proposed by A. M. Harding, Lafayetteville, Ark.*

Given the sum of the three sides of a triangle, the vertical angle, and the perpendicular from the vertical angle to the base. Construct the triangle.

Applied Mathematics.

122. *Proposed by Walter L. Brown, Fancher, N. Y.*

According to the law of gravity a mass with a given momentum acted upon from a given point by gravity travels in a conic; if it traveled in a semicubical parabola, $y^2=ax^3$, what would the law of attraction be?

SCIENCE QUESTIONS.

By Franklin T. Jones.

University School, Cleveland, Ohio.

Propose questions for solution or discussion.

Send in solutions of questions asked.

Send examination papers in the sciences.

In the May, 1908, number of School Science was published a committee report entitled, "Fundamentals in Physics."

Teachers will be interested in comparing the list of fundamentals there given with the college entrance questions given in June, 1908, by various examining bodies. The editor is sure that many teachers not now familiar with the questions mentioned will be astonished to find that the entrance questions are confined so closely to fundamentals. The questions set in June, 1908, by the College Entrance Examination Board, Harvard, Princeton, and Sheffield follow.

Ought not any student of average ability who has really studied to be able to pass 60 per cent on any of these lists?

How many failures are due to faulty English as much as faulty physics?

Are not the questions asked real tests of the studying done? [N. B. —There is a sharp distinction between "studying done" and "work covered." The certificate colleges lay emphasis on the latter only; the examination colleges aim to strike at the root of things by testing the former.]

Are not the college examination questions over a period of years a fair standard for the *work* that a *student* should do in one year ?

College Entrance Examination Board.

A.

Answer two questions from this group.

1. A balloon displaces 10,000 cu. ft. of air. Assume that air weighs .08 lb. per cu. ft., that the gas weighs .05 lb. per cu. ft. and that the material of the bag weighs 85 lbs. What lifting force will the balloon exert?

2. A pile-driver weighing 500 Kg. drops from a height of 5m. pushing the pile down 10 cm. What was the potential energy of the weight before it started to fall? What is the resisting force of the pile?

3. A ball is projected horizontally, with a velocity of ten meters per second, from the top of a tower 122.5 meters high. How long will it take to fall to the ground and how far from the tower will it strike?

B.

Answer one question from this group.

4. What three factors completely define a musical sound? To what characteristics of a wave do they correspond? What leads you to believe that all sounds travel with the same velocity under identical conditions?

5. Sound travels 332 meters per second in air at 0° C. and 0.6 meter faster for every degree its temperature is raised. What is the length of the wave in air at 20° C. produced by a fork vibrating 256 times per second?

C.

Answer one question from this group.

6. Distinguish between "quantity of heat" and "temperature" and explain what is meant by "the mechanical equivalent of heat."

7. Given 100 g. of water at 25° C. and 10 g. ice at 0° C.; what will be the final temperature of the mixture?

D.

Answer one question from this group.

8. State briefly what you understand by the "ether"; by "radiation." A 16 candle lamp is distant from a single standard candle one meter; where between them must a screen be placed so that it will be equally illuminated on each side?

9. Why do certain objects appear colored? Describe the formation of a spectrum.

E.

Answer two questions from this group.

10. Make a diagram of the form of a magnetic field; (a) about a bar magnet; (b) about a horse-shoe magnet; (c) about a straight conductor carrying an electric current.

11. How can it be shown that there are two kinds of electrification? How are induced electric currents produced and utilized?

12. What are the important contributions to Physics of three of the following men: Galileo, Torricelli, Newton, Faraday?

Harvard.

Omit four of the following questions.

1. A block of wood of volume 100 cu. cm. and specific gravity .75 floats in a certain liquid with two thirds of the volume of the block beneath the surface of the liquid; what is the specific gravity of the liquid?

2. On a certain day a mercury barometer reads 76 cm. at the base of a high building and 75 cm. at the top of the building. What is the height of the building? Take the density of mercury to be 13.6 grams per cu. cm.; assume the air between the bottom and top of the building to have a uniform density of .0012 gram per cu. cm.

3. (*a*) Define *dyne* and *erg*.

(*b*) How many dynes of force acting upon a mass of 10 grams for 2 seconds will give it a velocity of 100 cm. per second?

(*c*) How much work is done in the process?

4. A body starting from rest falls freely under the action of the earth's attraction.

(*a*) What will be its velocity at the end of 3 seconds?

(*b*) How far will it fall during the third second?

5. Make a clear sketch of two simple machines of different classes by which a force of 8 pounds can support a weight of 32 pounds. Indicate on the sketch the essential numerical dimensions of the parts of each machine.

6. Describe, with the aid of a diagram, one form of clock pendulum that compensates for changes of temperature.

7. How does the presence of water on the earth tend to prevent extremes of heat and cold?

8. Describe a compound microscope. Make a diagram, and show the principle focus of each lens and the path of the light rays.

9. If a printed page at a distance of one meter from a 16 candle-power incandescent lamp is illuminated to an intensity for comfortable reading, at what distance from an arc lamp of 2,000 candle power will the printed page be illuminated to the same intensity?

10. If an incandescent lamp requires a current of .5 ampere and a difference of potential of 110 volts at its terminals,

(*a*) How great is its resistance?

(*b*) How many such lamps may be supplied with power by a 2 kilowatt electric generator?

Princeton.

NOTE.—Applicants presenting certified note-books will answer the questions under B only. Those not offering note-books must answer the questions under both A and B.

A.

Answer any five.

1. Define a vector, an acceleration and an uniform acceleration. Why is the motion of a body rotating with uniform velocity in a circle uniformly accelerated?

What is the resultant of two equal parallel forces in the same direction? Of two equal parallel forces in opposite directions? What is this last combination called?

2. What is inertia? Describe three examples of the effects of inertia.

State Pascal's law, and tell how it may be confirmed experimentally.

3. What is sound? What is the distinction between noise and music? between melody and harmony?

Describe the determination of the velocity of sound in air by any method.

4. What is meant by "relative humidity"? How is it affected by a variation of temperature, while the amount of moisture in the air remains constant?

What is heat? What is the mechanical equivalent of heat?

5. State the modern—not the electron—theory of magnetism and outline the reasons for this theory.

What is an induced current? In what way may one be produced?

6. How do we know that white light is made up of lights of many colors?

What is the fundamental difference between lights of any two colors? Explain.

B.

Answer any five.

1. A ball, 1 kilogram in mass, is rotated at the end of a cord 1 meter in length at the rate of four rotations per second. What is the pull in the cord? In what units is it expressed? What is this pull called?

2. In a cylinder whose piston has an area of 20 sq. in., 600 cu. in. of air are under a pressure of 30 lbs. per sq. in. The pressure is increased to 120 lbs. per sq. in. If the average pressure during the compression can be taken to be 75 lbs. per sq. in., how much work must be done?

3. How many beats per second are produced when one note has 250 vibrations per second, while the other has 245?

A closed organ pipe is 60 cm. long. What must be the length of an open pipe which shall give the octave above?

4. The water at Niagara falls about 160 ft. Show how you can calculate how much its temperature will be increased by the fall.

If lead were permitted to fall the same height, would its temperature be increased more or less than that of the water?

5. What is the horse-power of the 110 volt generator which can just supply the current for 440 incandescent lamps which are joined in parallel, or multiple arc? Each lamp has a resistance of 220 ohms when lighted.

6. State the law of reflection of light.

A concave spherical mirror has a radius of curvature of 30 cm. An object is placed 75 cm. from the mirror. Where will its image be? Is it real or imaginary, erect or inverted?

Sheffield Scientific School.

1. If a body starting from rest moves a distance of 1,000 meters in 30 seconds under the action of a force of 50 dynes, what is the mass of the body?

2. Explain the principle of the ordinary thermometer and describe how the graduation is effected.

3. State what is meant by wave length, amplitude, frequency, and wave velocity. Write a relation which exists between some of these quantities.

4. What is the distinction between the primary, and the secondary or storage cell? Describe fully some primary cell with which you are familiar and point out any advantages or disadvantages it may possess.

5. What is an induced current? State what you can about the amount and direction of the induced current.

6. Describe different kinds of spectra and tell something of their origin.

NOTES.

RATIO AND DIVISION.

Professor Miller's article in the April number of SCHOOL SCIENCE AND MATHEMATICS contains (p. 299) a reference to a distinction often spoken of between ratio and division. May I ask what is the difference between a ratio and the quotient of a division? In other words, what difference is there between a/b meaning a divided by b, and a/b meaning the ratio of a to b? Some books do not define ratio at all, and those which do say it is "the relative magnitude of two numbers, expressed by the quotient of the first by the second." To make any distinction between this "relative magnitude" and the quotient which expresses it is like distinguishing between the length of a ten-foot pole and the distance ten feet, which expresses that length. There is no possible way of either expressing or conceiving of a ratio except as the abstract number by which one must be multiplied in order to produce the other—in other words, the quotient. Ray's Higher Arithmetic contains the express statement, "a ratio is a quotient," and every text-book, so far as I can recall, that I have ever seen, treating the theory of proportion, bases its demonstrations on the assumption that a ratio is a quotient. I am anxious to know what "confusion" arises from this "double meaning," if it indeed is a double meaning. The only reasonable definition of division is "the process of finding one of two factors, when the other factor and the product are given." Thus, if the product is \$10 and one factor is \$5, the other is the abstract number 2, which is the quotient, and is also the ratio between \$10 and \$5.

William B. Borgers, Grand Rapids, Mich.

AN OAK WITH A HISTORY.

NICHOLAS KNIGHT.

A large white oak, forty-three inches in diameter, in the timber land of George Barge, two miles southeast of Mount Vernon, Iowa, was recently cut down. Counting the rings, it was 273 years old, and solid throughout. In 1760, when the tree was 125 years old, a notch about one foot long and three inches deep was cut into it. The notch was completely filled with a cambium layer, and was hidden from view until the log was split. The tree had increased by a radius of nine inches since the notch was cut. For what purpose the notch was made, or by whom, can only be conjectured. It is not known that white men had penetrated so far into the interior of the country as early as 1760, and how an Indian could come into possession of a hatchet

in that day, unless he used an instrument quite unlike anything we know, is something of a mystery. Early in its history, the Hudson Bay Company had distributed such instruments among the aborigines, which may account for the notch. Whether the tree was cut into for a mark, or with the idea of felling it, the record of course has nothing to say.

DECAY IN WOOD PREVENTED.

It is estimated that a fence post, which under ordinary circumstances will last for perhaps two years, will, if given preservative treatment costing about 10 cents, last eighteen years. The service of other timbers, such as railroad ties, telephone poles, and mine props, can be doubled and often trebled by inexpensive preservative treatment. To-day, when the cost of wood is a big item to every farmer, every stockman, every railroad manager—to everyone, in fact, who must use timber where it is likely to decay—this is a fact which should be carefully considered.

It is easy to see that if the length of time timbers can be used is doubled, only half as much timber will be required as before, and only one-half as much money will need to be spent in the purchase of timber. Moreover, many woods which were for a long time considered almost worthless can be treated and made to last as long as the scarcer and more expensive kinds.

Of the actual saving in dollars and cents through preserving treatment, a fence post such as was mentioned at the beginning might serve as one example. The post is of loblolly pine, and costs, untreated, about 8 cents, or, including the cost of setting, 14 cents. It lasts about two years. Compounding interest at 5 per cent, the annual charge of such a post is 7.53 cents; that is, it costs 7.53 cents a year to keep the post in service. Preservative treatment costing 10 cents will increase its length of life to about eighteen years. In this case the total cost of the post, set, is 24 cents, which, compounded at 5 per cent, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

In the same way preservative treatment will increase the length of life of a loblolly pine railroad tie from five years to twelve years and will reduce the annual charge from 11.52 cents to 9.48 cents, which amounts to a saving of $58.75 per mile.

It is estimated that 150,000 acres are required each year to grow timber for the anthracite coal mines alone. The average life of an untreated mine prop is not more than three years. By proper preservative treatment it can be prolonged by many times this figure. Telephone and telegraph poles, which in ten or twelve years, or even less, decay so badly at the ground line that they have to be removed, can, by a simple treatment of their butts, be made to last twenty or twenty-five years. Sap shingles, which are almost valueless in their natural state, can easily be treated and made to outlast even painted shingles of the most decay-resistant woods. Thousands of dollars are lost every year by the so-called "bluing" of freshly sawed sapwood lumber. This

can be prevented by proper treatment, and at a cost so small as to put it within the reach of the smallest operator.

In the South the cheap and abundant loblolly pine, one of the easiest of all woods to treat, can by proper preparation be made to take the place of the high-grade longleaf pine for many purposes. Black and tupelo gums and other little-used woods have a new and increasing importance because of the possibility of preserving them from decay at small cost. In the Northeastern and Lake States are tamarack, hemlock, beech, birch, and maple, and the red and black oaks, all of which by proper treatment may help to replace the fast-diminishing white oak and cedar. In the States of the Mississippi Valley the pressing fence-post problem may be greatly relieved by treating such species as cottonwood, willow, and hackberry.

Circular 139 of the Forest Service, "A Primer of Wood Preservation," tells in simple terms what decay is and how it can be retarded, describes briefly certain preservatives and processes, gives examples of the saving in dollars and cents, and tells what wood preservation can do in the future. The circular can be had free upon application to the Forester, Forest Service, Washington, D. C.

WOOD FOR PAPER COSTS TWENTY-SIX MILLIONS.

The Publisher Pays Much More for His Stock than He Did Last Year.

To-day there is general complaint among publishers that printing paper is constantly growing dearer. In the Middle West many local papers are raising their subscription price 50 per cent in order to pay for the paper. From the time when Gutenberg first used movable type, made of wood, to the present day of metropolitan papers, some of which consume the product of acres of spruce in a single edition, printing has in very large degree depended upon the forest.

In the face of a threatened shortage of timber, the amount of wood consumed each year for pulp has increased since 1899 from 2 million to 3½ million cords. The year 1906 marked an increase of 93,000 cords in the imports of pulpwood, the highest average value per cord for all kinds, and a consumption greater by 469,053 cords than that of any previous year.

Spruce, the wood from which in 1899 three-fourths of the pulp was manufactured, is still the leading wood, but it now produces a little less than 70 per cent of the total. How well spruce is suited to the manufacture of pulp is shown by the fact that during a period in which the total quantity of wood used has doubled and many new woods have been introduced, the proportion of spruce pulpwood has remained nearly constant in spite of the drains upon the spruce forests for other purposes. During this time three different woods, from widely separated regions, have in turn held the rank of leader in the lumber supply.

Since 1899 poplar, which for years was used in connection with spruce to the exclusion of all other paper woods, has increased in total quantity less than 100,000 cords, and is now outranked by hemlock. Pine, balsam, and cottonwood are used in much smaller amounts.

New York alone consumes each year over a million and a quarter cords of wood in the manufacture of pulp, or more than twice as much

as Maine, which ranks next. Wisconsin, New Hampshire, Pennsylvania, and Michigan follow in the order given. Sixty per cent of the wood used in New York was imported from elsewhere, and even so the supply appears to be waning, since the total consumption for the State shows a small decrease since 1905, whereas the other states named have all increased their consumption. Other states important in the production of pulp are: Massachusetts, Minnesota, Ohio, Oregon, Vermont, Virginia, and West Virginia.

The average cost of pulp delivered at the mill was $7.21. The total value of the wood consumed in 1906 was $26,400,000. The chief item determining the price of paper is the cost of pulp. An example of the increased price of paper is found in the case of a publisher of a daily in the Middle West, who recently paid $1,200 for a carload of paper. The same quantity and grade of paper cost a year ago but $800.

The chemical processes of paper making, which better preserve the wood fiber, are gaining over the mechanical process. In 1899, 65 per cent of the wood was reduced by the mechanical process; in 1906, less than 50 per cent.

All importations of wood for pulp are from Canada, and comprised, in 1906, 739,000 cords, nearly all of which was spruce. Four and a half million dollars' worth of pulp was imported in 1906, a slight falling off from 1905.

Circular 120 of the Forest Service contains a discussion of the consumption of pulpwood in 1906, based on statistics gathered by the Bureau of the Census and the Forest Service. The pamphlet can be had upon application to the Forester, United States Department of Agriculture, Washington, D. C.—*Forest Service.*

A COMMUNICATION.

The Boston *Transcript*, June 27, 1908: "Say whatever you like, unless a thing can be verified, there is no real meaning in it."

"The [pragmatic] method is simply to put an end to philosophical disputes by inquiring what difference it would practically make to any one if this notion rather than that notion were true."

I was at once reminded of recent geometrical discussions. I should like to see treated in your magazine this topic: Non-Euclidean geometry —or perhaps better the foundations of geometry—pragmatically considered.

Yours very truly,

LUCY BEALES UPHAM.

Boston, Mass.

PERSONAL NOTE.

Mr. C. M. Westcott of Redlands, California, after eight years' experience in teaching Physics, three of which have been spent as head of that Department in the Redlands High School, left the profession at the close of the spring term to take charge of apparatus manufacture for F. W. Braun, the well-known apparatus dealer of Los Angeles.

A RESOLUTION.

At the meeting of the Secondary School Section of the N. E. A. at Cleveland the following resolution was introduced by Mr. E. W. Lytle, High School Inspector of the State of New York. The resolution was passed unanimously and is of such significance that we are glad to present it in these pages.

Mr. President: It became apparent from the discussions yesterday that the high school principals here assembled strongly favor the cosmopolitan rather than the differentiated high school. The arguments advanced were founded not on theory simply but on facts and thoughtful experience. Fundamentally our high schools are political, moral, and social agencies. Incidentally they should train for vocation; but their largest function is training for life. Separation into technical, business, and preparatory high schools inevitably encourages class distinctions, causes loss of social sympathy, and is not conducive to good scholarship. Moreover, differentiated schools make it far more difficult to correct mistakes, while differentiated courses render such corrections easy. Differentiated high schools also cause great loss of the student's time in travel to and fro.

In view of these considerations, I have been asked by many principals to introduce the following resolution:

Be it resolved that it is the sense of the Secondary Teachers of the N. E. A. that the building of differentiated high schools should be discouraged, and that the introduction of differentiated courses in all large high schools should be encouraged.

Sulphur deposits are being developed in the interior of the state of Tamaulipas, Mex.

The existence of but one absolutely flawless brown-coffee-colored diamond is known. Its weight is 3¼ karats and its estimated worth probably $40,000.

The following summary of the deterioration of coal was lately set forth in a bulletin of the University of Illinois, the authors of the paper being S. W. Parr and W. F. Wheeler: (a) An exudation of combustible gases from coal occurs from the time of breaking out of the sample from the vein; (b) an absorption of oxygen accompanies the exudation of hydro-carbons; (c) samples of coal in most carefully sealed containers are subject to deterioration; (d) the process of deterioration is probably due to oxidation of hydrogen or hydro-carbons by means of the absorbed oxygen. It may also be due to a simple loss of combustible gases and the replacement of the same by non-combustible gases and the replacement of the same by non-combusible gases such gases such as oxygen; (e) the rapidity or extent of this deterioration varies with different coals, but is probably most active during the first 2 or 3 weeks from the taking of the sample, but does not seem to reach a normal state till after a few months have elapsed. Further data on this point especially are necessary.

ARTICLES IN CURRENT MAGAZINES.

American Naturalist, July: "The Leg Tendons of Insects," C. W. Woodworth; "Abnormal Incisors of Marmota Monox L.," Charles A. Shull; "A Note on the Coloration of Plethodon Cinereus," Hugh D. Reed; "Some Experiments on the Order of Succession of the Somites in the Chick," Marian E. Hubbard.

Astrophysical Journal, July: "Upon the Magnetic Separation of the lines of Barium, Yttrium, Zirconium, and Osmium," B. E. Moore; "On the Sensitiveness of Photographic Plates at Different Temperatures," Robert J. Wallace; "The Relation of Light of Very Short Wave-Length to Some Vacuum Tube Phenomena," Theodore Lyman; "Observation on the Structure of the Arc," W. B. Huff; "The Relative Intensities of Spectrum Lines," P. G. Nutting.

Biological Bulletin, July: "The Ovogenesis of Hydra Fusa," Elliot R. Downing; "Notes on the Identification of the Chaelognatha," E. Le Roy Michael; "Effects of Alcohol on the Life Cycle of Infusoria," Lorando L. Woodruff.

Botanical Gazette, July: "A Study of Reduction in Oenothera Rubrinervis," Reginald R. Gates; "Studies in Aruaceal," James E. Gow; "The Embryo Sac and Embryo of Gnetum Gnemon," John M. Coulter.

Economic Geology, July-August: "A Graphic Comparison of the Allevation of Rocks by Weathering with their Allevation by Hot Solutions," Edward Sterdtmann; "The Copper Deposits of Kasaan Peninsula, Alaska," Charles W. Wright.

Forestry and Irrigation, July: "The Work of the Spoilers," A. B. Plowman; "Water Conservation in Arizona," W. B. Mershon; "Forest Tree Nurseries," O. R. Croft. August: "A Plea for the Nationalization of our Natural Resources," Henry Riesenberg; "Railroad Forestry Work"; "National Forests Redistricted.

Iron Age, July 23: "The Hamilton Coke Storage Machine;" "Power Required in Rolling Steel," J. C. Knesche; "Deposition of Zinc for Protecting Iron and Steel Surfaces."

Physical Review, June: "Distributed Capacity in Resistance Boxes," A. H. Taylor and E. H. Williams; "Vapor Pressure of CO_2," Sanford A. Moss; "The Influence of Humidity upon the Electrical Discharge from Points in Air," John Zeleny; "Effect of Mechanical Vibration upon Carbon Dioxide near the Critical Temperature, II," W. P. Bradley, A. W. Browne, and C. F. Hale; "Radioactivity of a Smoke Laden Atmosphere," S. J. Allen. July: "Further Measurements of the Coefficient of Linear Expansion at Low Temperatures," Herbert G. Dorsey; "Some Electrical Properties of Silicon, II. The Electrical Resistance of Silicon at Various Temperatures," Frances G. Wick; "Heat Developed in a Mass of Thorium Oxide, due to its Radioactivity," George B. Pegram and Harold W. Webb; "A Study of Dispersion in Highly Absorbing Media by Means of Channelled Spectra," S. R. Williams; "A Standard Battery," G. A. Hulett; "Ionization in Closed Vessels," W. W. Strong; "A General Formula for Dispersive and Resolving Powers," L. P. Sieg.

Popular Science Monthly, August: "The History of the Conservation of Energy: the Age of the Earth and the Sun," Florian Cajori; "Florissant: a Miocene Pompeii," T. D. A. Cockerell; "Crimes and Violence in Chicago and in Greater New York," Maynard Shipley; "The Movement towards 'Physiological Psychology,'" R. M. Wenley; "The Nature, Origin, and Function of Humor," Dr. Linus W. Kline; "A Bacteriological Study of Soiled Paper Money," Warren W. Hilditch; "Facts concerning Milk," Dr. A. E. P. Rockwell; "Shall Our Forest Wealth be Destroyed?" Thomas E. Will.

Scientific American, August 8: "The Mystery of Comets," J. F. Springer: "Progress of Excavation of Culebra Cut;" "The Opacity of Bones to Roentgen Rays as an Indication of Age," Jacques Boyer.

Technical World Magazine, September: "Mexico Puts Vast Falls to Work," Paul Adams; "How the Blood Defends the Body," E. F. Arnold, M. D.; "Counting of Natural Bridges," S. A. Culmer; "Tapping the Gunnison Canyon," René Bache; "Harnessing the River Nile," Hamilton Twesme.

Terrestrial Magnetism and Atmospheric Electricity, June: "Magnetic Declination and Latitude Observations in the Bermudas," J. F. Cole; "On Earth-Currents and Magnetic Variations," L. Steiner; "The Earth's Rendual Magnetic Field," A. Tanakadate, L. A. Bauer.

Zeitschrift für den Physikalischen und Chemischen Unterricht, Juli: B. Kolbe, "Ein regulierbarer Schul-Rheostat;" E. Schulze, "Apparat zur Huygensschen Ableitung der Formel fürsphysische Pendel:" H. Rebenstorff. "Versuche mit heissem Wasserdampf;" Ruoss, "Apparat zur Demonstration der Totalreflexion durchsichtiger und undurchsichtiger Körper;" Gg. Heinrich, "Das Kräfteparallelogramm."

BOOKS RECEIVED.

The Principles of Mechanics for Students of Physics and Engineering, by Henry Crew. Pp. 295; 1908. Longmans, Green & Co., New York. Price, $1.50.

General Chemistry for Colleges, by Alexander Smith. Pp. 529. The Century Co., New York. 1908.

Synthetic Inorganic Chemistry: A Laboratory Course for First Year College Students, by A. A. Blanchard. John Wiley & Sons, New York. 1908. Pp. 89. Price, $1.00.

Annual Report of the Smithsonian Institution, 1906. Pp. 546.

A Secondary Course in Agronomy, Circular 77. Office of Experiment Stations, U. S. Dept. of Agriculture, 1907. Pp. 43.

Magic Squares and Cubes, by W. S. Andrews, Chicago. The Open Court Pub. Co. 1908. Pp. 195.

Medico-Physical Works: A Translation of Tractatus Quinque Medico-Physici, by John Mayon, LL.D., M.D. (1674). Pages xxiii+331+five tables of figures. University of Chicago Press. Price, $1.36 post paid.

Report of the Commission on Accredited Schools and Colleges. 80 pages. Published by the Association. J. E. Armstrong, Secretary, Englewood High School, Chicago.

Bulletins of the University of Wisconsin. Published by the University, Madison, Wisconsin.

Annual Report of the Board of Education and the Superintendent of Schools of the City of Los Angeles. 170 pages. Commercial Printing House, Los Angeles.

Science Bulletins, University of Kansas. Published by the University, Lawrence, Kansas.

A Text-Book in Physics for Secondary Schools, by William N. Mumper, Normal School, Trenton, New Jersey. 411 pages, 420 cuts. 1907. American Book Company, Chicago.

High School Algebra, Advanced Course, by H. E. Slaught and N. J. Lennes. vii+194 pages. 1908. Allyn and Bacon, Boston.

A Laboratory Guide for Students in Physical Sciences, by H. Schapper. 12 mo; v+61 pages. Cloth, $1.00. John Wiley & Sons, New York.

General Physics, by Henry Crew, Northwestern University. xii+522 pages. The Macmillan Company, New York.

An Introduction to the Study of Electrical Engineering, by Henry H. Norris. 8 vo, v+404 pages, 179 figures. Cloth, $2.50. John Wiley & Sons, New York.

Seventy-first Annual Report of the Board of Education of Massachusetts. 352+cxxxiii pages. Wright & Potter, Boston.

Education by Plays and Games, by George E. Johnson. xiv+234 pages, 131 cuts. Ginn & Company, Chicago.

BOOK REVIEWS.

Bulletin 195 of the Office of Experiment Stations of the U. S. Dept. of Agriculture is upon the topic, "Simple Exercises Illustrating Some Applications of Chemistry to Agriculture." It presents twenty-eight well-arranged and very instructive experiments, also such a discussion of these experiments as to make them understandable and usable in any course in elementary agriculture or in connection with a course in elementary botany. O. W. C.

High School Algebra. By Slaught and Lennes. Pp. 194. Allyn and Bacon. 1908.

This book contains a review of all the topics treated in the Elementary Course by the same authors, and such additional topics as are required for entrance to college or technical school. The treatment is from a more mature point of view, and emphasis has been placed on the manipulation of forms. Indeed, it would seem that too much stress has been placed on such manipulation, for the concrete problems are needed here just as much as in the first year's work. In the lists of problems there are some good problems from geometry and physics. H. E. C.

College Algebra. By W. H. Metzler, E. D. Roe, and W. G. Bullard, Syracuse University. Pp. xiii + 341. Longmans, Green and Co. 1908.

The first six chapters, furnishing a brief review, are a fresh and scientific treatment of those topics, especially is this true of the treatment of complex numbers. The authors believe that the principal object is that the student should gain a knowledge of the underlying methods and principles; and they have developed the usual subjects of college algebra from this point of view. It is well written; much of the abstract has been omitted, and the average college student ought to be able to get some clear and definite notions from a study of this book. H. E. C.

A First Course in Algebra. By Webster Wells and Robert L. Short. Pp. 232. D. C. Heath and Co. 1908.

This book gives the pupil a good working knowledge of the subject through simultaneous quadratics. It is gratifying to see how the manipulation of abstract and complicated forms have given place to excellent problems of everyday life, geometry, and physics. The geometry problems are well chosen. The teacher who believes in uniting the different branches of mathematics can make these problems the basis of work in concrete geometry, and drawing which will serve as a preparation for demonstrative geometry, and lead the pupil to see the relation between algebra and geometry. The arrangement of topics is good, and the presentation of subjects in pairs: Addition and Subtraction, Fractional Equations and Proportion, and so on, simplifies algebra. The typography and mechanical construction of the book are excellent. H. E. C.

Elementary Algebra. By J. W. A. Young, Ph.D., Associate Professor of the Pedagogy of Mathematics, the University of Chicago, and L. L. Jackson, Ph.D., formerly professor of Mathematics, State Normal School, Brockport, N. Y. Pp. ix + 438. $1.12. D. Appleton and Co. 1908.

The aim of this book is to adapt the old material of algebra to the new requirements, and this has been done in a progressive, conservative manner. Especially is the use of the graph to be commended. It is not used as a thing apart from algebra, but is introduced early and used whenever needed to illustrate, and to solve problems; it is given to the pupil as a tool to be used when the occasion demands. Ratio, proportion, and variation follow fractions, and are treated more fully later. In all parts of the book the problems are new and are drawn in part from geometry, physics, and mechanics. The selection has been made wisely, and the teacher will find no great difficulty in explaining the simple physical principles involved since most of this has been done by the authors with good pictures and diagrams. There is an abundance of oral and written exercises, and the summaries and reviews at the end of each chapter will help to fix the pupil's knowledge. H. E. C.

The Check Figure, a complete explanation of all the principles involved, with examples illustrating its use, by G. O. Neff. 44 Pages; 1908. Price 60 cents. For sale by G. O. Neff, 18810 Sloane Ave. Cleveland, Ohio.

This little book is the product of many years' experience of an expert accountant. In any operation with figures, whatever its nature, the operator never feels it perfectly safe to rely without question upon the accuracy of the result. Slips of the mind are always possible; prolonged application will weaken the power of attention. But since correctness is the first essential in any result, some means must be adopted to test its accuracy. The author's long experience has enabled him to select the best and simplest method of testing the accuracy of any result. A complete explanation of the principles used is given.

The various uses to which the method may be applied; where it can be used with profit and where not; where, by reason of its defects, its results can not be relied upon; and how, in many cases, its defects can be overcome are clearly shown.

It is an invaluable handbook for those who are engaged in work requiring much arithmetical calculation. In its line there is nothing that will at all compare with it. C. M. T.

Our Trees and How to Know Them. By Arthur I. Emerson and Clarence M. Weed. J. B. Lippincott Company. Pp. ix + 295. $3.00.

Another photo-descriptive book of trees has just appeared, this one being the work of Emerson and Weed.*

The plan of the book resembles that of the book by Mr. R. B. Hough, recently reviewed in SCHOOL SCIENCE AND MATHEMATICS. Each species

of tree is given a page of description and a page of photographic illustration, the former having been prepared by Mr. Weed, and the latter by Mr. Emerson. One hundred and forty species are treated, the geographic range of these species covering most of the United States and Canada.

In the photographs are illustrations of the entire tree (some in winter and some in summer conditions), a bunch of leaves, twigs with buds, flowers and fruit. The photographs are good.

The text descriptions are brief and aim to give those distinguishing characteristics that will enable the amateur to recognize the different species. The various common names applied locally and generally to a given tree are presented, and will prove a means of interest and of clearing up a good many difficulties for tree lovers. The geographical distribution of each kind of tree is given and a brief statement as to the industrial use and appropriateness as an ornamental tree. In most cases at the close of the description mention is made of related species that are omitted from the fuller descriptions and from the photographs.

We have here an excellent illustration of how much photography may assist in presenting an important subject in a popular way. The book will be found valuable to a rapidly enlarging body of people who are interested in trees. O. W. C.

AN ORAL TEST.

How many of the following questions can you answer correctly:

What is Telepheme?

Is Hongkong a city?

What was the Geneva Bible?

What is a Swiss Canton?

How is Chauffeur pronounced?

What is a Treaty of Reciprocity?

What is a Statute of Limitations?

You may not be sure of all your answers and wish to know if you are right. Consult Webster's International Dictionary, the one great standard that answers with final authority all kinds of questions in Language, The Trades, Arts and Sciences, Geography, Biography, Fiction, Etc.

This reference work is a necessity in every well-equipped school, cultured home, and modern office. The publishers, G. & C. Merriam Co., of Springfield, Mass., will send you specimen pages upon application. If you mention this journal in your request, they will enclose a useful set of colored maps, pocket size.

The announcement in another column that A. H. Cole, 6022 Monroe Avenue, Chicago, is now the publisher of the "Manual of Biological Projection and Anesthesia of Animals" follows his recent purchase of the remainder of the edition, plates, and publishing rights. The "Manual" has already found place and praise in universities, colleges, schools of medicine, high and grammar schools. Its easy and practical methods add new interest and significance to studies with microscope and projection apparatus.

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Nebraska Teacher, Lincoln, Neb.
North Carolina Journal of Education, Durham, N. C.
Ohio Educational Monthly, Columbus, O.
Ohio Teacher, Athens, O.
Pennsylvania School Journal, Lancaster, Pa.
Popular Educator, Boston, Mass.
Primary Education, Boston, Mass.
School and Home Education, Bloomington, Ill.
School Bulletin, Syracuse, N. Y.
School Education, Minneapolis, Minn.
School Journal, New York, N. Y.
School News, Taylorville, Ill.
School Science and Mathematics, Chicago.
Southern School Journal, Lexington, Ky.
Texas School Journal, Dallas, Tex.
Texas School Magazine, Dallas, Tex.
Western School Journal, Topeka, Kans.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison.

A new twenty-four page circular entitled "New Instruments," just published by the Central Scientific Company, contains a number of new and novel instruments for the Physical Laboratory.

The most interesting are the following: A working model of Brennan's Mono-Rail Car, modified and improved by Drs. Crew and Tatnall of Northwestern University. This model is the first to be offered to the Schools, and is guaranteed to work in every detail. A new form of Electroscope that will hold its charge for several days will be appreciated. A Photometer Bench with all accessories, including a Universal Rotator and the Nodon Valve for rectifying alternating currents deserve careful consideration. A copy of this pamphlet will be sent free upon application.